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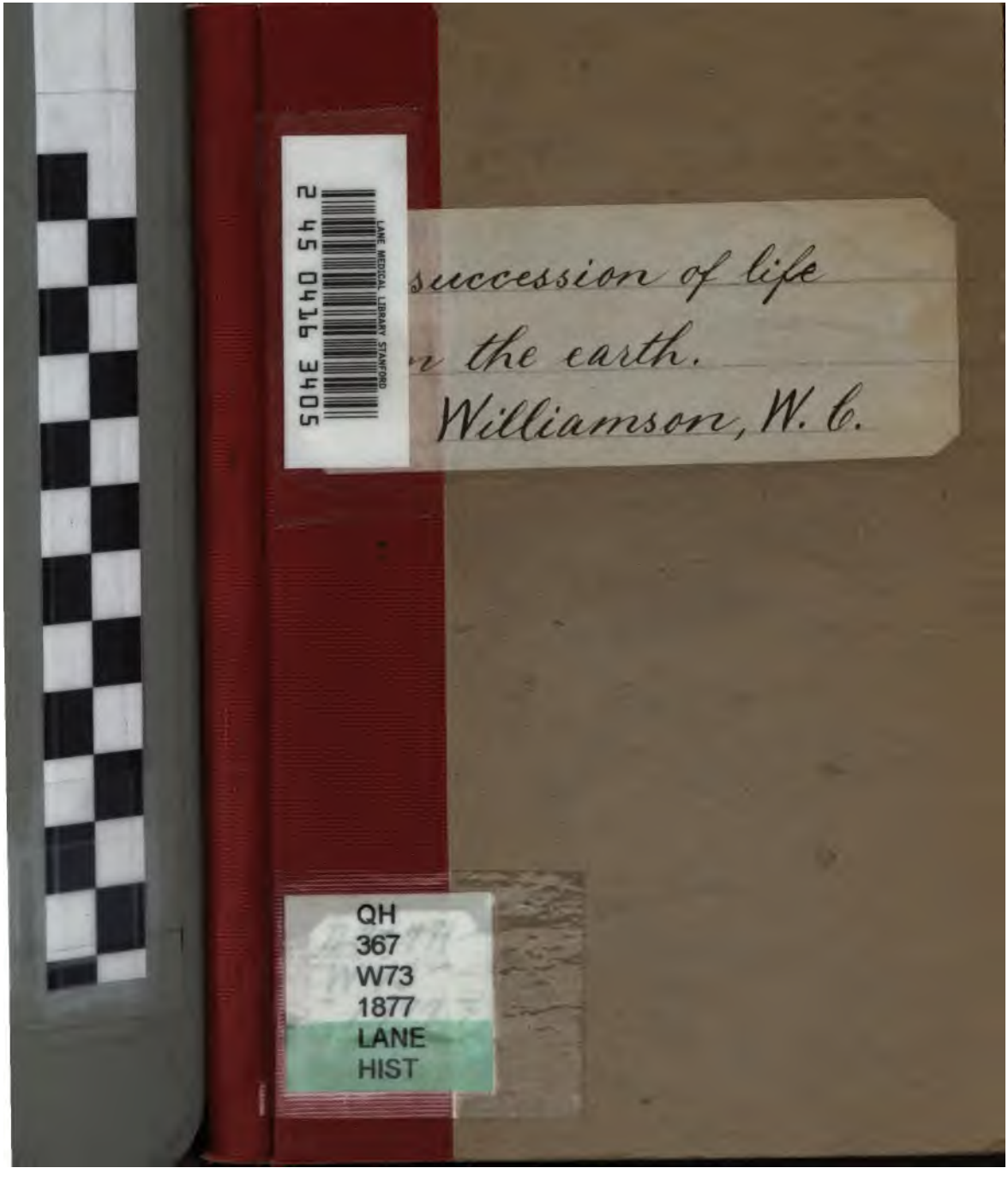
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THE SUCCESSION OF LIFE ON THE EARTH.

BY PROFESSOR W. C. WILLIAMSON, F.R.S.

LECTURE I.

When this course of lectures was arranged, it was thought desirable that you should have brought before you, in a brief but connected series, a general idea of what may be called the Cosmos,—the universe; and accordingly, arrangements were made, that our friend Mr. Lockyer should tell you about the Heavens, that Dr. Roscoe should discourse to you of the Earth, and that I should follow suit, in giving you a sketch of the history of Life upon the Earth. This then is the task that has been imposed upon me.

If it be true, as many of our scientific friends believe, that man has had an ancient ancestry very different from that which we are now inclined to recognise, it becomes desirable that we should have some sort of idea, who and what those ancestors were. We are told that man was once not only a monkey, but that there was a time in which he existed as some yet more obscure form of the lower animal creation, and from which form he has developed to what he is now. This is the doctrine of the Evolutionists; a doctrine in which I need scarcely say there is a large amount of truth; a doctrine

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that unquestionably explains much that has never been explained by any other hypothesis; but I have come to the conclusion, that though it does undoubtedly explain the origin of many of the lower as well as of the higher forms of animal life, I have never been able so to reconcile it with my knowledge of the facts as they stand, as to believe that it accounts equally well for the origin of man.

The study of the succession of animal life as it has appeared upon the earth is the study of an enormous number of isolated facts. Now isolated facts are always comparatively uninteresting. It is just in proportion as we can associate some general idea with those facts, and show that there exist points of union, links connecting them together, that they assume a new aspect, and exhibit a measure of interest they did not possess when standing alone. It is when thus viewed relatively to the doctrine of evolution, that facts concerning the origin and history of life appear to me to assume their newest and most independent interest. And it is in reference to this doctrine that I shall endeavour to expound to you the leading truths of the science. The doctrine of evolution presupposes that external influences, acting through enormously long periods of time, have altered the character, the wants, and the organisation of living things. But such changes could not be produced quickly; our own experience of what has taken place during the historic age shows us that such changes must have been slow. The crocodiles, oxen, cats, ibisses, and various other creatures that were embalmed amongst the mummies of Egypt, were animals such as still live on the earth without having undergone any change; the species are still identically what they were in the age of the Pharaohs.

In like manner, when we glance at the Assyrian sculptures, we see that the negro at the time of the Assyrian kingdom was precisely what the negro of the valley of Sennaar is still.

Here then we have proof that, in the examples in question, external influences, acting through thousands of years, have failed to make any material impression upon objects that flourish around us. If this be true, and there is no question that it is so, it follows, that we can never hope to test the doctrine of evolution by experiment. Man's life is short to enable him to obtain the necessary results. Where then must we look for evidence? I unhesitatingly say, it can only be derived from the rocks of which the

crust of the earth is composed. It is impossible for us to assign definite periods to the ages of these rocks; we cannot say how many thousands or millions of years slipped by whilst those rocks were accumulating; but we know that those periods must have been enormous. I doubt not, that we should be much safer in counting them by millions rather than by thousands; and it is in the rocks thus slowly accumulated, that we shall obtain satisfactory evidence of what time can do in permanently modifying organic forms of life.

But unfortunately the records which the rocks give us are imperfect, and they are so for many reasons. These rocks have accumulated, generally speaking, under the sea, just as sediments are accumulating now. Most of our dry land was under the ocean at a comparatively late period. At a period geologically recent the Alps and the Apennines, the Andes and the Indian Himalayas, were all beneath the sea. A map of Europe pointing out what was land and what was water at a very recent date, gives you altogether different outlines from those you have at the present time. Such changes in the sea-level have been going on perpetually, and the areas over which sediments, brought together by oceanic currents, were accumulating, have consequently undergone similar changes. Nor have they ceased to do so even at the present hour. At every period there were large areas of land separated by oceans, —and at each one of those periods both the sea and the land had, in all probability, their respective inhabitants; but many objects must have been living on the land that never reached the ocean; and even of the few terrestrial things that were entombed in the sea, remembering at how few spots the geologist has opened the bowels of the earth, you will see that many chances exist against the probability of such rare relics being stumbled upon by the fossil-hunter.

Let me give you an illustration of what I mean. We have for some time past been dredging the ocean in all directions; expedition after expedition has gone forth, culminating in that noble and successful one of the *Challenger*. Through these agencies the deepest parts of the sea have yielded many sub-marine treasures, but has there been any one solitary instance, in the whole of these dredgings, in which a human bone has been fished up from the depths of the ocean? Not one; and yet we know that thousands of unhappy mariners are immersed for ever in that ocean each year of our existence. If then we merely trusted to what the dredge has brought up,

such results would tell us nothing of the life of man upon the earth. And so it must have been in all ages It can only have been by fortunate combinations of circumstances that any particular deposit could give us a fair conception of what the life was, that existed upon the earth when that deposit was found.

If we examine the rocks composing what we call the crust of the globe, we discover a succession of layers arranged one upon another. The section on the screen may be taken to represent roughly a wide area, ranging from the central mountains of some continent to the sea, and such a section may approximately represent the structure of the outer portions of the earth's crust along a line hundreds, or even thousands, of miles in length. We here see that the lowest are the most ancient beds, and as we ascend from the lower to the upper strata, we arrive successively at those that are of more recent date. Of course if we merely dig into the earth at some few points, various parts of this series will be wanting; uplifted by volcanic and other causes, the rocks have frequently been tilted up on their edges, and since many of these uplifted portions have been swept away for thousands of vertical fathoms of thickness, by what we call denudation, it follows that many of the more modern rocks, though once existing at such spots, may have disappeared. We also find from observation that some of the more ancient rocks—as for instance those that form the mountain peaks of Snowdon and parts of Westmoreland—have not probably been entirely immersed under the sea for thousands, if not millions of years. And hence, while more recent deposits were accumulating in other parts even of the area now occupied by our own island, those particular parts may possibly never have been in such a position in relation to the sea as to enable them to receive a covering of the newer deposits. Thus you see, that, at many spots, we may fail to find the more modern strata, partly because they never accumulated at those spots, or after having accumulated they may have been swept away again by those vast denuding influences which have done so much to alter the physical structure of the surface of the globe. Nevertheless, if we begin on the south-eastern coast of England, and travel towards Snowdon, we shall cross the uplifted vertical sections or "outcrops" of most of the known rocks, beginning with [illegible] modern ones at the mouth of the Thames, passing [illegible]*essively the* Chalk-hills of Hertfordshire, the Oolitic lime-

stones of Northampton, the Red-sandstones and Coal-bearing strata of Stafford, until we finally reach the ancient slates of Snowdon and the Welsh borderland. Now you know very well that if a bricklayer begins to build a wall, he does not commence by hanging his top layer in mid air, and then building downwards; he puts his first layer of bricks on the solid ground, where he can obtain a good foundation, and then proceeds to build upwards upon this foundation.

And as a general rule we may safely affirm that this has been the case with the rocks of the section before you, as well as of this other one which shows the approximate relative thicknesses of the various layers that form the crust of the globe. At its base we have a series of strata only found in America—the Laurentian rocks, named from the river St. Laurence—near whose shores they are at least 30,000 feet in thickness. Above these is another series of American rocks, which possibly are also to be found in the Hebrides—these are the Huronian beds, probably 18,000 feet thick.

Then we come to some of our own Welsh and Westmoreland mountains, where we find the Cambrian strata, which add 15,000 feet more. Yet higher we have the Silurian and other Welsh and Westmoreland rocks, 32,000 feet thick. Others, known as the Devonian beds, still higher, are from 10,000 to 14,000 feet. It is unnecessary to follow the section to its top. Enough has been said to show what an enormous mass of rock we have to account for; and yet every particle of that mass has been slowly accumulated by agencies which, depositing atom after atom, continued their action through incalculable periods. When you observe how slowly such accumulations progress at the present time—and we have no other standard whereby we can judge of their rate of progress in past ages—we are driven to the conclusion that this pile of strata represents periods which the human mind can scarcely conceive of. During these periods, forces, which we call Forces of Nature, but which are merely the instruments of the Divine Architect of the world, have been in incessant operation, and it is to some of the results of that unceasing action, in connection with once living things, that we have to look to-night.

If it be true, as the doctrine of evolution requires us to believe, that animal and vegetable life began with some obscure germs, out of which, as ages rolled on, other and more complex objects were developed, and that in this way

plants and animals gradually increased in the complexity of their organisation as the world grew older, then, we should expect to find something corresponding with this order of development in the order in which plants and animals appear in the rocks. In the lecture of to-night, I hope to guide you in this direction, through what is called the Palæozoic age, the age in which many of the forms of life were very different from those now existing, but throughout much of which period certain types of organisation are found to prevail. Near the very bottom of the Laurentian series there has been found in Canada a very extraordinary object, a small magnified portion of a section of which is represented in Fig. 1. This is declared to be the oldest known fossil. There is some dispute as to whether it is a fossil, or a mere mineral

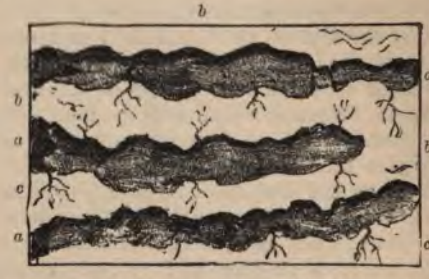

FIG. 1. – Portion of a section of Eozoon canadense. (*a*) Cavities occupied by the living animal. (*b*) Calcareous layers secreted by the animal. (*c*) Branching canals in the calcareous layers.

organisation. It is called the *Eozoon*, which means the "dawn of life." Now that this is a fossil I have no doubt whatever; if so, it is the earliest trace we have yet met with of any animal form. We know that there are certain little objects now living in the sea called Foraminifera; objects that possess microscopic shells made out of lime which they extract from the sea-water; and as the animals perish, their dead shells sink through the ocean and accumulate in its depths, where they form vast deposits of calcareous mud. The valley of the Atlantic is largely filled with these deposits. Each of these microscopic objects lives an independent life; they are minute—the largest recent Foraminifer I have seen equalling the size of half-a-crown; and living forms of magnitude are very rare; generally speaking they are like

the dust that we see blowing about the roads on a dry summer's day. And yet, put them under the microscope, and you discover that they are really organic atoms which often display exquisite beauty. Now the probability is that the Eozoon was a creature allied to these Foraminifera, but instead of existing as a multitude of minute and separate protoplasms, as is the case with our living forms, in the Eozoon these protoplasms blended to form thin extended layers of jelly superimposed upon each other. As myriads of minute polype animals combine, at the present day, to form coral-reefs many miles in length, so the united protoplasms of the Eozoon constructed vast reefs of foraminiferous shell. Assuming these opinions to be correct, what position does this primitive creature occupy in the scale of organisation? It is as near the bottom of that scale as it well can be. The only objects with which we are acquainted that are lower, are certain microscopic, infusorial creatures, little specks of jelly-like protoplasm, that are found in both fresh and salt water, and of which it is absolutely impossible that any trace could be preserved in a fossil state. Thus far then the earliest known fossil creature presents itself in a form consistent with the idea of evolution. The rocks reveal no further indication of organic life until we ascend to the series called Cambrian, found amongst the mountains of Wales, Westmoreland, and elsewhere. This group of rocks was chiefly investigated by that noble-minded man, the late Professor Adam Sedgwick of Cambridge, whose ceaseless energy, bright intelligence, and manly character, long will cause his name to retain a foremost place in the annals of English science. At a comparatively low horizon of this Cambrian series there have been found at one or two localities, but especially at a place called Bray-Head near Dublin, the remarkable objects to which the name of Oldhamia has been given. These objects are found in such quantities that layer after layer of the rock is composed of them. That they are organic, and not mere mineralised forms, the result of crystallisation, is indisputable. We are not absolutely certain what they were, but we have every reason for supposing that they were Corallines, allied to those found so abundantly on our sea-coasts.

This second fossil naturally suggests the question, What is the position of the Corallines in the scale of nature? We have ascended to a considerable height in the series of rocks and we *should* expect, according to the theory of evolution,

have made some advance in the organisation of any fossils which those rocks may contain. There is no doubt that the Corrallines come next to the Protozoa, to which group the Eozoon belonged; they occupy a higher position, but it is still low compared with what is to follow. Thus far objects continue to be arranged in their right order. When we ascend still higher in this series we come upon an extraordinary set of forms of wonderful diversity. The oldest shell that we have found is a minute creature, differing from the ordinary shells with which you are familiar. It belongs to a group well known to the conchologist and geologist as Brachiopoda, and of which the best-known are called Terebratulæ and Lingulæ. These creatures occupy a position in the scale of organisation a little lower than such shell-fish as oysters, cockles, and mussels. It is to this somewhat lower group that the Obolella—the first form of shell-fish that has been found amongst the Welsh mountains—belongs. I do not mean to say that this is the oldest shell that ever lived; I merely say that it is the oldest of which we have found any trace. A little higher up we come upon a remarkable outburst of life; we arrive at a part of the Cambrian series in which we find a number of extraordinary creatures, called Trilobites. They are "crustaceous" creatures, allied to crabs and lobsters, but occupying a lower position in the crustacean series than crabs and lobsters do. Associated with these, we find fossil sponges, somewhat similar to those you are familiar with at the present day. These well-known objects began to make their appearance upon the earth even at this early period. Associated with these sponges and curious crustaceans, we also come upon objects known as Encrinites, representatives of which are still living in our seas. These are animals very closely allied to star-fishes, but which, instead of being free and able to wander hither and thither, are planted upon a fixed stalk. The stem does not afford nourishment to the star-fish at its top, but the star-fish affords nourishment to the stem; and although it has certain root-like organs, these do nothing for the creature beyond fastening it in the sand, in which it chiefly resides. They do not draw any nourishment from that sand as the roots of a tree would do; they merely fix the creature there. The mouth, which is in the middle of a terminal series of branching arms, receives the food that those arms entangle; and it is this part of the creature—the star-fish part—that nourishes the stem and roots, and not the stem and

roots that nourish the fish. These Encrinites now begin to be comparatively abundant; we shall find them still more as we ascend higher. Thus we see that we have already made a somewhat important advance in the development of animal life. Ascending still higher, we reach the Silurian group of rocks, for the investigation of which we are chiefly indebted to the labours of Sir Roderick Murchison. We were long

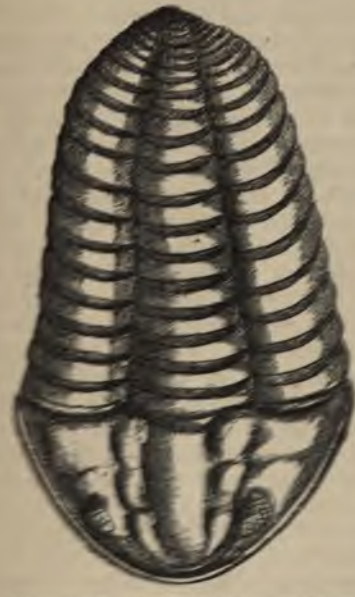

Fig. 2.—Upper surface of a Trilobite from the Silurian rocks.

familiar with the fact that, running down the border-land between England and Wales, there was a long line of fossiliferous limestones, of which little was known; they were only recognised by the vague name of Transition limestones. We merely knew that they were thought to be somewhat more modern than the older slate rocks, and somewhat older than the coal-beds of the neighbourhood of Manchester. But Murchison found that these rocks were as capable of being studied and arranged in chronological order as any other rocks with which we are acquainted, and the publication of

his great book, entitled *The Silurian System*, gave us the clue wanted to the understanding of the entire series. It turned out that this Silurian series of strata, which had been so long neglected, was not only richly fossiliferous, but was quite as much so as any rocks seen in other portions of the fossiliferous series. On entering this new region we still find that most of the types met with in the Cambrian beds lived into the Silurian age, though the species were different; we still have the Sponges and Encrinites. The Trilobites still occur, and sometimes in extraordinary profusion; in fact this Silurian age was the one in which they culminated; being more abundant then than at any period before or after. In the Arctic seas at the present day there are certain small creatures so abundant that when a whale opens its jaws and takes in a mouthful of water, after squirting the water out between the plates of whalebone, which serve as teeth, it retains a huge mouthful of these small objects. There must have been something like this in the ancient Silurian seas, because two of these Trilobites, the Trinucleus and the *Asaphus Buchii*, occur in such numbers, that entire strata largely consist of their remains. We now come upon certain things that we have not hitherto seen. We find, for instance, a group of extraordinary objects, called Graptolites. For a long time we doubted what these were, but they are now understood to be a remarkable group of Corallines. They were not found in the Cambrian beds, nor have we found them at a later period than the Silurian. I may refer here, whilst speaking of these Graptolites, to the great discovery which first erected geology into a science, and which was made by the veteran friend and tutor of my younger days—I mean the late father of English geology, William Smith. Previous to Smith's day the rocks were unclassified, because we had no means of estimating accurately their relative ages. Smith however discovered that in all this pile of strata—at all events in such portions of it as he was familiar with—each stratum or group of rocks possessed organic remains that were characteristic of that group, and that were not to be found in any other. Consequently, just as when you disinter some accumulation of buried antiquities, you see by the stamp upon the coins whether they belonged to Greek, Roman, or mediæval times, so the geologist, taught by Smith, learned to recognise, not, it is true, the actual age, but the relative age of the rock which he *happened to be* inspecting, by means of what my old friend

Dr. Mantell termed the "medals of creation." By this he meant the peculiar fossils which that rock enclosed within its stony matrix.

In strict accordance with Smith's theory, when we find these Graptolites we have every reason to believe we are dealing with Silurian rocks. In these rocks we also come across star-fishes. Thus you see we are steadily advancing into the midst of things with which we are still familiar in a living state. When we reach the middle and upper part of this class of rocks we find Corals extremely abundant; we find remains of Corals even among the Cambrian beds; but when we reach certain deposits in the middle and upper part of the Silurian system, we have the clearest evidence of the existence of tropical seas, because Corals like those that now flourish only within thirty degrees of the equator, have been as abundant as they now are in tropical regions. The limestone beds of Dudley, in the iron district, are almost entirely made up, in some places, of vast accumulations of tropical Corals. But besides these, we also find that there has been a rapid development in molluscan life during the Silurian age; and not only so, but we find here a remarkable development of that highest type of molluscan life known by the name of cuttle-fishes. I do not mean to say that we have actually found the cuttle-fishes themselves, but we have found shells which we know must have been embedded in the soft tissues of cuttle-fishes. When I tell you that some of these shells must have been seven or eight feet in length, you may judge what must have been the size of the living cuttle-fishes to which they belonged. Now mark what this means. Recollect how comparatively low our position still is in the scale of stratified rocks, and remember that these cuttle-fishes not only occupy the highest position in the scale of molluscan life—that is, the life of shell-fish—but that in many instances they approximate so near, in some parts of their organisation, to the vertebrate section of the animal kingdom, as almost to constitute a connecting link between the one and the other. For instance, the cuttle-fish has a brain enclosed in a cartilaginous cranium, a brain-pan made of gristle. Now here we clearly have an approach to the skull of the vertebrate type of animals. Still further; the cuttle-fish has special ganglia, or masses of brain, set apart for the exclusive purpose of giving origin to the nerves of sight. This is precisely what occurs in our *own bodies*. The nerves of sight in the human body

arise from two special nervous ganglia, the "optic ganglia", and we find two perfectly distinct ganglia, one on each side of the brain of the cuttle-fish, from which its nerves of vision proceed. Thus we see that, in more respects than one, these cuttle-fishes and their innumerable allies, not only occupy a high position in the scale of molluscan life, but they almost form a stepping-stone across the boundary which connects the molluscs with the vertebrate animals. In the Silurian age not only were these cuttle-fishes represented by the Orthoceras, but we find other external chambered shells of the same general type corresponding to the living Nautilus.

But we must advance yet a step higher. There have been found in the uppermost parts of this Silurian series of deposits the remains of fishes which are met with here for the first time. One of these fishes, the Cephalaspis, so much resembles a large Trilobite in form that, when first found, we need not be surprised at its having been mistaken for one. Further investigation, however, showed very clearly that it was a true fish. It might readily have been supposed that the Cephalaspis was a crustacean in course of development into a fish; but the peculiar shape which suggests this idea is only one of those outward resemblances, devoid of real identities, that are apt to mislead imaginative minds. When we examine the organisation of this object, we find that it had genuine bones like other fishes, and that its hard structures were altogether distinct from the peculiar integument that constituted the protecting covering of the crustaceans.

But associated with this Cephalaspis there also existed in the later Silurian days another fish. And now comes one of the perplexing facts which geological investigation has brought to light, and which appear unfavourable to the doctrines of development and evolution. Murchison first showed that in the upper Silurian beds there existed the remains of species of shark, and other observers have verified the statement. When we inquire what position the sharks occupy in the scale of fish-organisation, we learn that they occupy its summit. They possess at the present day a brain organisation which brings them extremely near to the reptiles. There is every reason to suppose that the particular fossil found in these Silurian beds is not only a shark, but that he belonged to one of the highest

barks. We have here a seriously awkward fact.
parently taken a step forwards, in advance of
ween these sharks and the lowest forms of fishes

there exists a vast series of fishes such as we see in our markets, but which have apparently no representatives in this ancient epoch. In the first place, if you take a salmon or a cod-fish you will see that its vertical tail divides into two nearly equal lobes; and if you trace its long vertebral column or backbone, you will see that it terminates midway between the upper and the lower lobes of the tail; but no such fish is to be found in any of these more ancient rocks. Before we can find fish like the recent ones, so far as the tail is concerned, we must reach the Oolitic period. Up to this point of time all the fishes that we find are either sharks, or belong to another great group, the Ganoids, of which I shall have to say a word or two presently. Here, then, I repeat, we have a difficulty. We cannot bridge over the gap which connects these sharks with the lower forms of animal life which I have been endeavouring to describe. What future research may do to remove this stumbling-block we cannot tell—but at present it does stand as a serious hindrance to our unreserved acceptance of the evolutionary theory.

But we must now pass another of the boundary lines dividing separate groups of strata, when we shall reach the Devonian beds; these are a very remarkable series of rocks, the relations of which have only become intelligible to us of late years; but they will have a special interest for some of you, if, as is probable, I have some Scotchmen amongst my audience. It was from amongst this series of Devonian beds that one of the brightest intellects of Scotland fought his way up from wielding a stonemason's hammer to becoming editor of one of the ablest of the Scotch newspapers, and the author of some of the most eloquent descriptive books ever written by mortal pen—I mean the late Hugh Miller. Now Miller, and others who followed in his footsteps, brought to light from this Devonian series of rocks a very remarkable set of fossils. I won't dwell upon the shells and other curious objects found in these rocks, for time is short, but I will call your attention to some of the fishes with which he first made us acquainted. One of these is the Pterichthys, an extraordinary-looking fellow, with two wing-like appendages hanging by his side, and covered with an armour of large angular plates that remind us more of a tortoise than a fish. The Coccosteus is another, and if possible still more curious fish, with a tadpole-like head, resembling in shape those black and slimy froglets and newtlets that dabble at the margins of our ponds in early spring. But besides these examples we have other modifications

of the Ganoid fishes, in which rhomboidal scales overlap each other like the slates of a house, and in which the vertebræ of the tail run very conspicuously into the upper lobe.

The group to which all these fishes belong is not yet quite extinct. It continues to be represented by the bony pike of North America, and a similar fish, called the Polypterus,

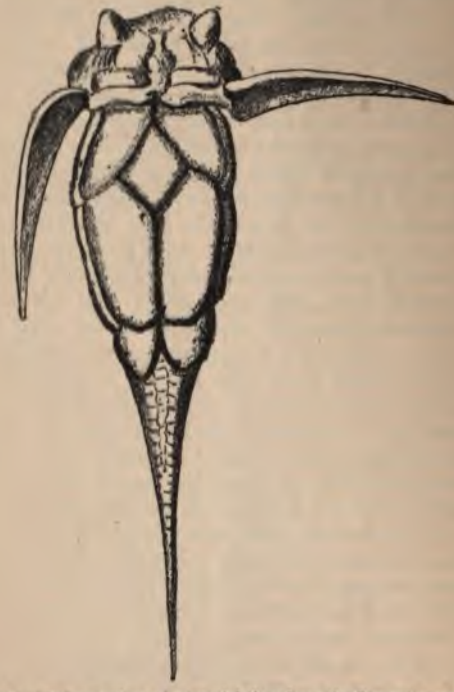

FIG. 3.—Under surface of a Pterichthys from the Devonian rocks.

is found in the Nile and in other rivers of Africa. In addition to the scales of these fishes differing from those of the cod and salmon in outward form, they are also much more bony in their internal structure. Ascending through the whole of this pile of ancient rocks, we discover no kind of fish except members of the shark tribe, including their relatives the ganoid fishes, until we reach the Chalk strata.

We still find in this Devonian bed the Cephalaspis, which continued to linger through the earlier parts of the Devonian age. But, before we leave this age I must introduce to you another acquaintance whom I have previously neglected but whose race began its career during the epoch of the upper Silurians which we have already considered. He is called the Eurypterus, and is a sort of half-developed lobster. He grew to the stature of an adult, whilst he retained some of the organisation of his earlier life. He seems as if his limbs had forgotten to grow along with his body. But when I tell you that he was often six or seven feet long, you will see that he would afford an excellent dinner to one of the lobster-loving sharks of that ancient date. He disappeared entirely at the close of the Devonian age, and there has been nothing like him since. I suppose the sharks of that period ate him up, and there was an end of him. "We shall not look upon his like again."

Thus far I have made no allusion to the vegetation existing on the earth. We find vague traces of plant-life in the Silurian and Cambrian beds, but, so far as we can ascertain, those plant-remains are merely fragments of seaweeds; we have no very definite evidence of anything higher than seaweeds existing in those older days. For a long time we were equally unaware that any higher flora lived in the Devonian age; but my friend Dr. Dawson, of Canada, has, within the last few years, revealed to us the existence of magnificent forests during this geological period. This flora corresponds very minutely in all its general features with that seen in the coal-beds surrounding Manchester.

For instance, we find in it extraordinary Calamites, huge plants allied to the horsetails of the present day. Then it contained Lepidodendra, gigantic representative of the dwarfed, living club-mosses, but instead of creeping along the ground, and barely lifting their heads twelve inches from the soil, these were magnificent trees, rising 100 feet into the air. Then we also had a rich array of ferns. We must not overlook the notable fact that in these Devonian beds this wonderful flora bursts upon us with almost the suddenness of a flash of lightning. Most of its plants are what botanists call cryptogamic; that is, plants that have no flowers, but merely develop what are termed spores, and not true seeds. But side by side with them we find a wonderful display of coniferous plants, allied to the tribe of pines and firs, and which we know to be flowering and seed-bearing plants; but

they are flowering plants of a very peculiar type. Whether we may consider them as having a higher or lower organisation than oaks or elms, is a point on which opinions differ; but our best botanists incline to regard them as connecting the cryptogamic Lycopods on the one hand, with the flowering trees on the other. There exists no evidence showing that any of our ordinary forest-trees grew on the earth in this Palæozoic age. Up to the close of this vast period the flora was confined apparently to these cryptogamic plants and conifers. We must

Fig. 4.—Pinnule of a Fern from the coal-measures.

not overlook the notable fact that this wonderful flora bursts suddenly upon us. We have yet found no indications of a previous and less highly-organised flora, out of which that under consideration might have been directly developed, at the same time it is possible that some such may have existed without any traces of it having been preserved in the older rocks.

We must now leave the Devonian age, and come to the

Carboniferous beds, that is, to the group of strata to which our British coal-measures belong. These, of course, are beds that interest us in every sense of the word, and were I to deal fully with them it would take an hour, even to clear the ground. I need scarcely say that the Carboniferous age has left rich blessings to mankind. Though it is not the only geological period which has supplied the world with that invaluable article of fuel which we call "coal," it is undoubtedly *the* period in which the finest and most widely diffused beds of coal were accumulated, and consequently our manufacturing interests owe more to this than to any other series of deposits. Not only is it our chief source of coal, but it is also that from which we draw our most valuable supplies of iron. So that here we get, side by side, the raw materials for the construction of our machinery, and the fuel by which that machinery is to be worked. At the time when the coal-measures began to accumulate our country exhibited very different outlines of land and sea from what it does now. If we go to the lowest of these Carboniferous strata in Western Yorkshire and Derbyshire, we there find the rocks in the shape of grey limestones—the Derbyshire limestone, with which most of you are familiar, and of which you make use in building your garden-rockeries; on visiting Derbyshire you see these limestones, rising on all sides, constituting the vertical cliffs that add such a charm to Derbyshire scenery. The fossils which they contain show that these limestones have been accumulated in a deep sea, which covered Derbyshire and the adjoining parts of Yorkshire. But when we cross over into Fifeshire and the neighbourhood of Edinburgh, we find that these thick strata of marine limestones are altogether absent. Whilst Derbyshire was deep under the ocean, there flourished in North Britain magnificent forests, analogous to those I have been describing as existing in the Devonian age By and by, however, in our midland part of the country, the sea gradually became filled up with its accumulating organic sediments, in addition to which it is probable that the land itself slowly rose, and after passing through a transition period, in which sea seemed to struggle with land for the mastery, we arrive at what we call the Mountain coal mines. These are a series of very thin coals, which run along the hill-sides of Halifax and Oldham, and one of which, cuts horizontally through the top of Rivington Pike. Every bed of this coal represents the beginnings of an ancient forest. As

yet the forests of this district evidently had not attained to any prolonged duration, as is indicated by the thinness of the coal seams; but when we rise a little higher we come to the rich coal-mines round Wigan, such as the Arley mine and others, with beds of coal from five to seven feet thick, and which have been entirely produced by the decay of the leaves, branches, and prostrated trunks of the forest-trees which accumulated on the ground where the coal-beds now exist.

We have now reached dry land and forest life. There is evidence amongst these beds that not only did plants grow, but that land-shells flourished under their shade; two land-shells having been found in coal-beds of this age in Canada. One is a true snail-shell, and the other is a Pupa—a genus of

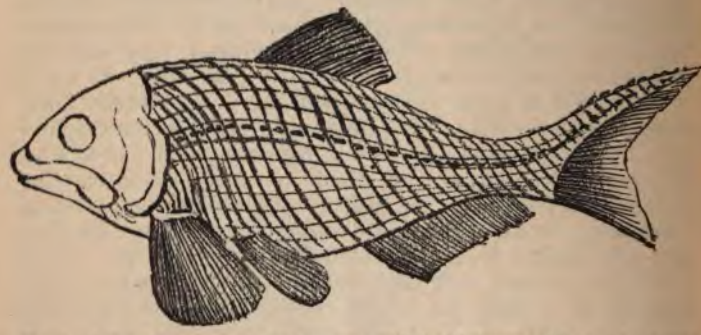

Fig. 5.—A Ganoid fish from the coal-measures with the "heterocercal" tail, *i.e.*, having the vertebral column prolonged into its upper lobe.

molluscs allied to the snails still found living in our own woods. If you were to examine the trees growing in the damper parts of Bowdon Woods I have no doubt whatever that you would find shells of the same kind adhering to their bark. We have also clear evidence that insects abounded at this period. Spiders, too, were not wanting, spiders of large size having been found in some of the ironstones of this Carboniferous age. Numerous shark-like fishes were associated with equally numerous Ganoid ones in the deeper waters, all [illegible] fishes having the "heterocercal" tail of Fig. 5, which [illegible]nts a Ganoid from the coal-measures. In the marshes [illegible]ries there existed numerous Batrachians, or rep- *to the* frog and newt; but some of which must

have been almost as large as crocodiles. Combining all these facts, we find that so far as animal life is concerned we are steadily rising in the scale of organisation, and approaching nearer to living types; but so far as vegetable life is concerned, we are still in the same position as we occupied in the Devonian age. We find now that amongst the trees there still are gigantic horsetails, relatives of those which you see in our ditches and ponds at the present time; the latter plants are generally not more than a foot or eighteen inches high, though occasionally reaching to four or five feet: of which size I have found them in the damp parts of Derbyshire. But what size were these fossil "Calamites"? I have specimens of these ancient horsetails in my cabinet that must have been twenty or thirty feet high, and with stems nearly as thick as my waist. Then we have the plants already referred to as allied to our club-mosses. I mean the Lepidodendra and Sigillariæ, and we find that they often rose to 100 feet in height. We have in the Owens College museum a carefully-made cast of one of these huge stems, discovered at Dixon Fold, on the Manchester and Bolton Railway, and which measures twelve feet in circumference near its base. How very peculiar must have been the aspect of forests composed of such gigantic cryptogams!

There was also an undergrowth of ferns and smaller horsetails, with here and there a few Tree-ferns vainly aspiring to rival the aristocratic Lycopods that towered above their heads, and on the drier uplands the pine-forests appear to have flourished apart from their cryptogamic neighbours. There is evidence that the climate of that Carboniferous age was not that of our temperate region. We have reason to suppose that it was a warm one, but we have no proof that it was tropical in its character. Whatever it was, it was the same in Greenland, in Central Europe, and in Australia, since in all these remote localities we discover similar fossil plants in the Carboniferous beds. There must have been a peculiarity in the physiognomy of these Carboniferous forests. No flowering plants gave local colour to the landscape. There were no grassy meadows covered with daisies and buttercups, or rich moorlands glowing with the purple and gold of heather and furze. The entire aspect of the vegetable world must at that time have been something like what Mr. Wallace tells us is so characteristic of tropical forests in the present day, where we see *every shade* of green. The earth is ladened with the

luxuriant vegetation which it supports, but you have no masses of flowers giving distinctive colouring to the landscape. You have, it is true, individual trees that are rich in their gorgeous bloom, but they are isolated and lost in the verdant expanse. Such also must have been the hue of the woodlands which flourished in the Carboniferous age.

As we ascend through the Carboniferous rocks we find that marine objects become gradually fewer in number. In the older beds a great many of the types of shells that characterise the Silurian and Devonian ages still flourish. We find Corals and Encrinites; we also discover a few small Trilobites which still linger, but which now take their departure and we see them no more; but as they disappear we have evidence that their place is being taken by the living Crustaceans that may be regarded as the nearest relatives of these Trilobites—I mean the curious Limuli, or king-crabs, now found in the tropical parts of the world. The king-crab, which exists in the seas of many tropical regions, is very like the Trilobite in its structure and general appearance; and the advocates of evolution would contend that the king-crab was evolved from the Trilobite. Be this as it may, I can only say that we have the last descendants of the expiring Trilobites preserved in the Carboniferous rocks, and, side by side with them, we have the Limuli beginning their race of life. The former are the latest of all known Trilobites, whilst the latter are the earliest of all known king-crabs; but there is not the slightest indication of any transmutation of the one into the other of these two fossils. Of course it is not impossible that there may have been embryonic links establishing a transition from the Trilobite to the Limulus, but geology gives no evidence whatever of the existence of such links. The Limuli are very definite in their shapes, and cannot by any stretch of the imagination be made to merge into the little worn-out Trilobite that was evidently coming to the end of its days.

Above these Carboniferous rocks we have a group called the Permian beds, upon which I will not dwell long. If you go to the neighbourhood of Collyhurst, near Manchester, you will probably still find traces of an old quarry, called the Vauxhall quarry. That quarry was well known thirty years ago, because it was from it that the Manchester iron-founders of that *od obtained* sand for constructing moulds in which to *their iron* castings. Now that sandstone rests upon

the coal strata, and forms the base of this Permian series of rocks. Then there were found, not far from Vauxhall, a few thin layers of limestone ; and in the neighbourhood of Bedford, near Worsley, these limestones are a little more fully developed. These limestone rocks contained peculiar fossil shells characteristic of the Magnesian limestone, which is a member of the Permian series.

On going eastward across the Lancashire hills we come to a series of beds of yellow limestone, which you will see in cuttings in the neighbourhood of Wakefield and Normanton ; these again are the same Magnesian limestones as those thinner ones found in Lancashire. When we reach Durham we find this same limestone still further developed, attaining, in that district, a thickness of something like 500 feet. It is obvious that the sea in which these limestones were deposited was a shallow one in western Lancashire, and deepened as we approach the Durham coast. This Magnesian limestone— so called because it contains a small percentage of Magnesia mixed with calcareous matter—is rich in fossil remains. Many of these remains are peculiar. They are fossils that we have not found in the Carboniferous beds below, or in the Triassic beds above ; some of these Permian beds are often exceedingly rich in the remains of Ganoid fishes ; but though the species are distinct, the types are similar to some found in the Carboniferous strata. . . . The chief importance of these beds to us now is found in the circumstance, that in the neighbourhood of Bristol the remains of reptiles of a higher order than any we have hitherto met with have been found in them. These reptiles are partly allied to the lizards, and partly to the crocodiles.

Thus we see that so far as we have accomplished our ascent from the lowest to the highest strata, race has been supplanted by race, generation has followed generation ; occasionally we have seen evidence that seemed to indicate the existence of links connecting a departing race with another that succeeded it ; suggesting the possibility of a gradual transition having taken place from lower to higher forms as years rolled by. There are also broad general indications of an upward progress, shown by the introduction, from age to age, of animals having a higher organisation than those which preceded them. But nothwithstanding this we are obliged to admit, that when viewed in minute detail, the rocks which we have examined *give but a very limited* support to the doctrine of evolution.

I will not dwell upon this subject now, because I shall have to give you a slight *résumé* of the matter in the concluding lecture of the series. I have thus far guided you only through the Palæozoic series of rocks; and that but hastily and imperfectly, because of the limited time at our disposal. I have only been able to give you a bird's-eye view of the country over which we have been travelling; trusting that you will again go over the ground by yourselves, and in a more detailed and leisurely manner.

LECTURE II.

In my last lecture I conducted you through what is called the Palæozoic period of geology. You will recollect I pointed out to you, in that lecture, that geologists roughly divided the time, during which the earth has been undergoing geological transformations, into three great ages: the Palæozoic, or ancient age; the Mesozoic, or middle age; and the Cainozoic, or recent age.

The Palæozoic age, which we dealt with last Tuesday, is characterised equally, as we saw, by the creatures which lived in it and by the creatures which did not then exist. We found that there were special types of living things which flourished, more or less, throughout even the later portions of that age. But we now cross a boundary line, beyond which we find evidence of a great change. I do not mean to say that all the genera we shall meet with are wholly new, because such is not the case. On the contrary, there are large numbers of types and patterns that appeared upon the earth in the earliest portions of its history, which never passed away again, and which are living at the present time; but, whilst this is perfectly true, it is equally so that, at the boundary line we are now crossing, like passing from one hemisphere to another, we leave behind many things that we have become familiar with, and are brought face to face with new forms of organic life. The boundary line of which I now speak comes high up in the scale of rocks. Judging from the immense pile of strata through which we have already ascended, you might suppose that we were arriving near the end of our journey. But this is very far from being the case. You will learn, as we proceed, that, though the thickness of the remaining strata is insignificant, the interest of their organic contents, and the vast changes which those organisms have undergone, becomes increasingly remarkable. There seems to

have been a marvellous quickening in the power of developing life as the world grew older. During the earlier stages of the vast Palæozoic age, the progressive development that took place advanced much more slowly than it did towards its close—and we shall find that after entering upon the Mesozoic period, the rapidity with which that development increased becomes more and more marked as time advances.

Leaving the Palæozoic rocks, we come to the base of the Mesozoic series, represented by what are called the Triassic formations. These are strata with some of which you have the opportunity of becoming sufficiently familiar, because the most conspicuous of them is that red sandstone which you see extending in so many directions around Manchester, but especially throughout the whole plain of Cheshire. The red sandstone, and the marls that surmount it, are especially rich in the rock salt which is extracted from the salt-mines of Northwich and various other parts of Cheshire. But it is not with the physical and inorganic features of this age that we have now to do.

At the same time I must just mention that there exists in the middle of this series of Triassic rocks in Germany a comparatively thin limestone-bed that is rich in fossil shells. The occurrence of this "Muschelkalk" is rather important to us, since we happen to have in Britain no representative of this stratum, and, but for its existence elsewhere, we should have been very ignorant of much of the life of the Triassic age. The Triassic rocks seen in England are extremely barren of fossils. At the same time they do afford us some information which we shall find to be significant. In the first place, the Muschelkalk tells us that the family of Encrinites is still represented; all the types of this group which are found so abundant in the Palæozoic beds have disappeared; every one of those numerous species have become extinct. In their place, in this German Muschelkalk, which, translated into plain English, merely means "shelly limestone," we find a new Encrinite, a true member of the Crinoidal family

yet altogether different from those whose place it has

The question inevitably arises, "How and whence has

Encrinite come?" It is very distinct from those

ferous rocks; merely preserving the general plan

cording to which they are all constructed; we

set it with any of the extinct forms as to suggest

that it has descended directly from them; it

is the isolated known representative of the vast race whose place it has taken so far as the Triassic strata are concerned.

Then there are shells peculiar to this age, but I need not dwell upon them. Most of them are merely useful to the geologist in helping him to identify the particular rock that he may happen to be examining. But the case is different when we turn our attention to some extraordinary creatures which, in all probability, once roamed over the very spot where you are now sitting. The history of these creatures is decidedly peculiar. In the first instance there were found, at Corncockle Muir, in Scotland, some slabs of sandstone, the surfaces of which exhibited impressions of what were evidently the footsteps of four-footed creatures. These impressions were generally found on marls that were covered over with a bed of sandstone. The impressions in the clay were hollow, and of course the sandstones that filled up these hollow impressions were in relief. It very soon became clear that, whatever the creatures were to which these marls owed their existence they had been living things that had walked upon a half-sandy, half-muddy tidal shore, and had left their footsteps as they travelled along, which footsteps had become hardened by the sun before the returning tide was able to wash them away. These impressions afterwards became covered with layers of sand, which protected their sharp outlines from injury, until they were once more brought into daylight by the labours of the quarryman. We have strong reasons for concluding that these footsteps were formed on a tidal shore, and the evidence that leads us so to conclude is of a kind that is perfectly available to every Manchester man. As you walk through the streets of Manchester you may have noticed the difference between the flags of our pavements and those you find in the towns of western Yorkshire ; for whilst those of Yorkshire are almost as smooth as the platform upon which I stand, those of Lancashire are rough, often marked with irregular, wavy ridges and furrows, not altogether comfortable to walk upon. Now what do these ridges and furrows mean? You can easily answer this question for yourselves if you recall the similar irregularities constantly left by the retiring tide on the sands of Southport and Blackpool. When tidal waves are moving slowly over a layer of mud or sand, some remarkable movement of the water, that is not clearly intelligible, produces these ridges and furrows. The sandstone from which we have obtained these fossil footsteps often exhibits ridges and furrows

exactly similar to those recent ones to which I have called your attention; and as we never see them excepting where there has been flowing water, and especially tidal water, we come to the conclusion that the sands on which these footsteps were impressed were covered periodically by the tidal wave.

The next question is, by what sort of being were these footsteps made? We must go to different parts of the world for a full response to this query. These footsteps have been found very abundantly in our own Cheshire district; magnificent examples of them occur near the village of Lymm, and another remarkably fine set of them was discovered at the Storeton quarries, near Liverpool. Examining these footsteps more minutely, we see, in the first place, that there are two sets of them; there is one series of very large impressions produced by a large foot; and alternating with these is a corresponding series of much smaller ones. Since these impressions very much resemble those which would be made by pressing the outspread palm of the hand upon soft, wet sand, before any remains of the creature which made them had been found the latter was called the Cheirotherium, or beast with a hand. From the regular alternation of large impressions with small ones it was clear that the fore and hind feet of the creature had varied greatly in their dimensions, and further examination led to the conclusion that the smaller feet had belonged to the fore-limbs and the larger feet to the hind ones. The probability that this was the case led naturalists to conclude that the animal had been a huge Batrachian, a near relative of the frogs and newts. In time a few of its bones and teeth were discovered; and so far as they went, they gave support to the above conclusions. After this, still more perfect examples were obtained, which leave no doubt that geologists were correct in the opinions they had formed respecting the nature of the Cheirotherium. But before this identity of the foot-prints and the fossil bones was established, the name of Labyrinthodon had been given to the latter by Professor Owen, owing to a remarkable labyrinthine pattern exhibited by transverse sections of the teeth, peculiarities which he described and figured in one of his works. This was one of the most remarkable animals living in which I am speaking. Not that it appears here for the first time; later researches have shown that similar creatures existed amongst the marshy forests of the Carboniferous

age. Not only have magnificent skulls of this creature been found in the coal-beds near Glasgow and other places, but impressions of his footsteps have been found, similar to those belonging to the Triassic period. Owen's name of Labyrinthodon is now generally identified with this strange creature, in which science, art, and commerce, meet very strangely together. When Owen obtained the first of its teeth, he found in transverse sections of it the labyrinthine structure, to his figure of which I have already called your attention; very shortly after that drawing was published it reappeared in Manchester, forming the centre of a printed pocket-handkerchief!

Even in England the footsteps of several other reptiles appear along with those of the Labyrinthodon. Some of these footsteps look much like those of tortoises, but whether this is really the case or no, we are not sure. In some limestone beds near Bristol there have been found the bones of some reptiles of unquestionably higher organisation than Batrachians, whilst at Elgin, in Scotland, besides a small lizard-like animal, the remains of a huge crocodilian creature have been disinterred from beds which are now generally admitted to be of the Triassic age.

However remarkable the footsteps of our British reptiles may be, they are insignificant compared with what occur abundantly in the United States. Such footsteps have been found there in immense numbers, and of at least twelve species of lizards, tortoises, or turtles, and Batrachians. But here another type of footstep abounds—viz. those of at least thirty-two species of three-toed bipeds, believed to be those of birds like the ostrich—but some of which must have been four times as large as the living ostrich, and yet of the actual remains of all these numerous creatures no fragment has yet been discovered in the sandstones of Connecticut.

Turning to the Triassic plants, we discover that the old Coniferous species of the coal-measures are gone, and are replaced by other forms, such as the genus *Voltzia*, which is altogether new. We do, however, find in these Triassic beds some representatives of the Calamites, or ancient horsetails, which are so common in the coal-measures, but they are feeble representatives of their ancestors. As these ancient horsetails disappear, their place is taken by the true modern horsetails, which we find for the first time in the newer Triassic rocks of the neighbourhood of Strasburg and elsewhere. We call this

fossil genus Equisetites, to distinguish it from the living Equisetums; but I have no doubt, both from the organisation of its stem and the peculiarities of its organs of fructification, that it is a true horsetail, differing chiefly from the living ones in the large size to which it attains; instead of the diminutive plant we now find in our marshes, it grew to a height of twenty or thirty feet. Interested in the origin of this Equisetites, I made a journey to Strasburg to examine the specimens in Professor Schimper's well-known Strasburg museum. I wanted to see if I could detect anything in the Triassic Calamites, found in that district, that would show a transition from the Calamitian type of the coal-measures to this Equisetaceous type; but I could not find the least indication of transition from the one to the other. The characteristics of each of these two appeared to me perfectly definite, and not in the least to merge into each other. Whether any transitional form ever will be discovered, uniting the ancient to the modern forms, remains to be seen; but at present geology reveals no such transition. The old race, which we found to be most abundant and widely prevalent through the age of coal, as well as through the Devonian period, now dies out under the influence of agencies unfavourable to its continued life, and a new one takes its place, coming we know not how or whence.

We further find in these Triassic beds traces of a group of semi-tropical plants called Cycadeæ, which do not occur in these temperate regions, but which abound just outside the tropical zones of both the Old and New Worlds, where the tree-ferns, india-rubber plants, and pepper-trees flourish. Recent investigations have made it more than probable that some of these plants flourished in the Carboniferous age.

But I must now cross another of the boundary lines which separate one age from another. We pass from the Triassic to the Oolitic strata. At this point of transition we meet with some new phenomena. In the first place, there have been found in two or three parts of Europe—including our own country—some fossil teeth of a true mammalian quadruped, and found so near our last boundary line, that opinions have differed as to whether the fossils belong to the Oolitic rocks above or to the Triassic rocks below. We have hitherto seen no representative of this division of the animal kingdom. Hence, so far as we now know, this "Microlestes," as the creature to which these teeth belonged is called, is the oldest *mammalia*.

It is somewhat dangerous to attempt to reason from a few solitary teeth as to the nature of the animal to which they may have belonged; but the probability is that it was either a Marsupial creature, that is a creature somewhat allied to the Opposums of America and Australia, or if not that, to some animal of a closely-allied type. I shall have to refer again to the question of Oolitic mammals as we proceed; I merely mention it now because of the position in which these remains were found. For some time after the discovery of this animal it was generally regarded as an Oolitic fossil, but later investigations indicate that it really belongs to the upper part of the Trias; be that as it may, it constitutes the first known example of that profuse mammalian life that is now so abundant on the earth.

Before actually crossing our new boundary, I must call your attention to a most extraordinary and anomalous state of things existing at two localities in South-eastern Europe. I have told you that throughout the world many of the Palæozoic types of life disappeared even before the close of the Triassic age; but at Hallstadt and St. Cassian, the Palæozoic and Mesozoic ages seem to have overlapped in a most exceptional manner. We have found nothing like it in rocks of this age in any other part of the globe. At these spots we find many of the Silurian and Carboniferous types, which we thought had disappeared altogether, intermingled with some of the most characteristic fossils of the Oolitic strata—a combination which is altogether of an exceptional character.

These Oolitic rocks are so designated because they contain a large number of limestones made up of little rounded granules, which resemble the eggs, or what you commonly call the roe, of fish. So close is this resemblance, that you might imagine lumps of limestones to be the petrified ova of some fish. We now know this is not the case; these little rounded atoms are merely the results of mineral changes which the rocks have undergone after their original accumulation; we can observe similar "Pisolites," as they are called, forming in "Travertins," or modern calcareous accumulations precipitated from hot springs in several parts of Italy.

The Oolitic age has been very appropriately designated the "age of reptiles." It certainly was a period in which reptiles were the dominant creatures; and such is often their peculiarity of form that we may say to each,

"Thou comest in such a questionable shape."

When you examine the extraordinary things represented in my diagrams, I think you will admit that this Shakespearian passage is strictly applicable to them. Were I to describe all the forms of animals that occur in this Oolitic age, I should detain you longer than our time will admit of my doing; so I must select certain salient ones upon which to dwell. We still discover remains of the lower form of animal life, such as the sponges, star-fishes, and Encrinites. The various types of marine shells now multiply in a very rapidly-increasing manner, compared with what we found to be the case in the rocks lower down in the geological scale. Not only so, but every individual species that we discover is new, and, in many cases, the large groups of species which we call *genera* are equally new. I will give one illustration of what I mean. I spoke to you of the Brachiopoda, those extraordinary shells which are so abundant in the Cambrian, Silurian, and Carboniferous ages. There are certain of these Brachiopoda represented by two well-known genera, which are the centres around which many other similar genera are grouped; I mean the genus Productus and the genus Spirifer. Now these two names represent two vast groups of species of shells, which occur in enormous numbers in the Palæozoic beds; but they have all gone out of existence, with the exception of one or two solitary forms that have just survived long enough to reach the base of this Oolitic age where they finally disappear. Ascending to the higher mollusca, we come to a very remarkable change in the opposite direction. I spoke to you the other day of the existence of Cuttle-fishes in the ancient age, and pointed out that even in the Cambrian and Silurian beds we had shells that unquestionably belonged to that group of molluscs. There is living in the sea at the present day, especially in the seas of the Malay Archipelago, a well-known shell, designated the Nautilus. This Nautilus has a spiral shell, with numerous transverse partitions dividing its interior into a series of chambers, whilst the animal constructing the shell resides in a large terminal chamber. This means that originally there was but one chamber, in which the very young mollusc lived, but as the animal grew it enlarged its shell to make room for its growing body. If you look at the outline of the soft animal you will see that he has a rounded base, and that for it to have dwelt in the open mouth of a tapering cavity, where there was nothing to prevent his being incon-

veniently pressed backwards into the narrowing portion of a spiral cone, must have been far from comfortable. We should be in a similar position if required to sit in a large chair, the seat of which was made like an inverted extinguisher. But

FIG. 6—Diagram of a Cuttle-fish containing a Belemnite. (a) Chambered shell or Phragmacone of the Belemnite. (b) Solid extremity of the Belemnite.

the Nautilus escapes from this uncomfortable position by shutting off behind it such portions of the shell as are too narrow for its body; it effects this by constructing a transverse partition of shell, the concavity of which fits accurately to the outline of the posterior part of its body. In whelks and periwinkles no

arrangement is needed, since, in them, the animal always corresponds in length and form to the entire cavity of its shell. The animal which makes itself comfortable in the way described is merely a modified Cuttle-fish. There are two great groups of these creatures, both of which are represented in a fossil state —viz. those whose shells enclosed their bodies, as in the Nautilus —and those whose bodies enclosed the shell, as in most of the Cuttle-fishes. Both these types abound in the Oolitic rocks. In a few cases the entire Cuttle-fish, with its contained chambered shell, is perfectly preserved. You will remember we believe this to have been the position of the gigantic Orthoceræ, met with in the rocks belonging to the Carboniferous and Silurian ages. That gigantic Cuttle-fishes formerly existed is probable enough, since a huge one has been discovered on three or four occasions living in the Atlantic, of which the body and arms together are more than thirty feet in length.

The study of these Cephalopods, as the entire group of Nautili and Cuttle-fishes is called, affords an interesting illustration of the progress of life on the globe. In the Cambrian and Silurian ages we had true Nautili and Cuttle-fishes, and in the Carboniferous age we again find similar objects; but associated with the former we now find a new nautiloid shell, called Goniatites, to be very abundant. There is a bed of ironstone, called Ganister running through our Yorkshire and Lancashire uplands, which is full of these Goniatites; this genus is essentially characteristic of the Carboniferous age. When we come to the Triassic age we find that the Goniatites are gone, and are now represented by another genus, the Ceratites. On crossing the boundary separating the Trias from the Oolites, we find that the Ceratite has disappeared in its turn, but we find in vast numbers, associated with true Nautili, creatures known by the name of Ammonites. These Ammonites are spiral shells, like the Nautilus, with this difference, that while the divisions between the chambers in the Nautilus are simply concavo convex, in the Ammonites their surfaces undulate in an extraordinary manner; so that their margins, as seen on the surface of the fossils, look more like the foliage of a tree than anything connected with molluscan life. These Ammonites accompany us all through the Oolitic period; from the Liassic rocks up to the top of the Chalk which surmounts the Oolitic pile of strata, they are extremely common, but they are confined to the rocks of the Oolitic and Cretaceous ages. Associated with these Ammonites throughout the same periods

we find true Cuttle-fishes, and also curious fossils, which have long been known to the provincial mind as "thunderbolts." In shape they remind us somewhat of Sir Jos. Whitworth's pointed shot and shell. Formerly it was the popular belief that every flash of lightning was accompanied by the fall of a "thunderbolt;" and the ignorant multitude identified these oblong fossils with the supposed electric product. They are, however, merely chambered shells, somewhat like the Palæozoic Orthoceras, but in which the chambered portion occupies only the upper and inner part, whilst the lower part is weighted by a solid, investing, semi-crystalline mass.

In the Cretaceous period other Nautiloid forms known as Hamites, Ceratites, &c., abound—forms only found in the Cretaceous strata—but on entering the Tertiary age all these Oolitic and Cretaceous types pass away leaving only forms of Nautili and Cuttle-fishes, similar to those which still flourish in our existing seas.

Leaving these mollusca and advancing to a higher stage, we come to fishes and reptiles, and here it is that the marvels of the Oolitic age begin to present themselves. The fishes are still confined to the two groups, the *Ganoids* of Agassiz and that containing the sharks and rays, but in many of the Ganoids we now find, for the first time, the posterior extremity of the vertebral column terminating on the centre of the tail. (See Fig. 9.)

It would be vain to attempt to dwell upon a tenth part of the reptilian forms that characterise this age; I can only select a few of them. The seas in which these reptiles lived were probably tropical, since, in many parts of the range of hills extending from the coast near Scarborough to the banks of the Severn, we find the limestones abounding in corals of the tropical type and not unfrequently existing in the form of true coral-reefs. One of the strangest of the reptiles is the Ichthyosaurus; a formidable creature of great size and power, aquatic in its habits. When I tell you that he was often from 20 to 30 feet long, that I have seen the teeth three inches in length, and that his immense head is furnished with long rows of them, you will admit that he is not exactly the kind of creature one would like to encounter when bathing. Associated with this gigantic fellow, was the gentler and more graceful animal called the Plesiosaurus. He lived in the same seas, and was, like the Ichthyosaurus, an aquatic animal; both of them were carnivorous; of that there is no doubt, because in some of the

specimens, we have actually found in the place where the stomach ought to have been, the remains of their last meal, and can thus identify the fishes upon which they fed. Leaving these great Ichthyosaurian reptiles, I come to another huge creature known by the name of Megalosaurus. This was a gigantic land reptile, constructed somewhat like a kangaroo, with the hind limbs prodigiously large in proportion to the

FIG. 7.—Skeleton of the Pterodactyle. (a) Four free inner digits furnished with terminal claws. (*bb*) Outer digits sustaining the membranous wings.

fore ones; whether these gigantic hind limbs were made for leaping or for running we do not know. Another saurian is called the Cetiosaurus, meaning the whale-like saurian, of which a fine series of bones is preserved in the Oxford Museum. This creature was evidently built in the heavy type of the whale; at the same time there is no doubt he was a reptilian animal. In the Museum at Whitby you will

find the remains of several other saurians, including those of a Teleosaurus or crocodile, with a long and narrow head and snout. It so happens that this creature has left a very near relation in the world. Those who have visited India and dipped into the Ganges may know something of the Indian crocodile, known by the name of the Gavial, which is extremely like the Teleosaurus; the latter was doubtless an amphibious creature, equally prepared to take a meal on land or in water, wherever he could best catch one. Still more marvellous is the Pterodactyle, a huge flying reptile whose name merely means that his digits supported wings; and there is no question that this creature was a real flying dragon; probably the only real flying dragon the world ever saw, since those of ancient fables certainly have no existence. When this fellow's wings were outspread they sometimes measured fifteen feet from tip to tip. I think you will say that the Roc was not more likely to alarm poor Sinbad the Sailor than one of these Pterodactyles would have done had it swept past him into the valley of diamonds. When we come to the Wealden beds, which are a local group intermediate between the Oolitic and Cretaceous series, we find these Pterodactyles associated with another wonderful group discovered by my old friend, the late Dr. Mantell, the well-known Sussex geologist. These new forms correspond with the Iguana, a large lizard found at the present day in the West Indies. Here again gigantic size characterised our objects. I remember Mantell showing me, in his collection, a thigh bone of one of these lizards, which was four feet eight inches long, and of proportionate thickness, even in its imperfect state. Now realise what that means—a lizard with a thigh-bone four feet eight inches long. If you examine the thigh-bone of any living crocodile, you will find it less than a foot in length. From this comparison you will be able to estimate the proportions of these ancient monsters. I have in my own cabinet a fragment of one of these thigh-bones, the dimensions of which when entire must have been even greater than those I have named. Remembering the above facts, I think you will acknowledge the perfect appropriateness of the declaration that the Oolitic and Cretaceous rocks belong to "The Reptilian Age." But we have not yet done with the animals of this period. At Solenhofen, in Bavaria, whence we get our lithographic stones, the skeleton of a bird has lately been found. The notable feature of this bird is seen in *his tail, which* was long, slender, and tapering, reminding

us of the tail of a lizard. If you examine living birds you will find that, in every case, the bony members of their tails are not only short and compact, but all their tail-feathers are attached to the very last joint of the tail, which is enlarged to allow of their being planted upon it. I repeat that in all living birds the entire series of the tail-feathers is attached solely to the last joint of the tail and to no other; but when we examine this very remarkable fossil-bird we find not only a long tail, but each of its bones has one pair of feathers attached to it and no more. There are twenty pairs of true feathers. Such is the earliest form in which indisputable remains of birds present themselves to our notice. I may remind you here that no fragments of the skeletons of the supposed birds which produced the Triassic footsteps of the Connecticut Valley have yet been discovered. Strangely enough, out of the enormous number of these creatures that must have existed, not one solitary fragment of bone, feather, or tooth has been found to give a clue to the nature of the animals that thus left their foot-prints on the sands. If these were birds, of course the one now under our notice came very late into the world; if they were not birds, but two-legged reptiles, as some geologists believe—then this Archæopterix is the oldest bird with which we are acquainted.

I have yet to say a word about the flora of the Oolitic age, which consists either of the Conifers, plants of the pine tribe, or of the remarkable allied group known as Cycads, to which I have already called your attention. Through the Oolitic age we find no trace whatever of the modern types of forest trees; not one solitary leaf, fruit, seed, or fragment of wood of any kind has been obtained that indicates the presence of any other type of arborescent plant than the firs or pines, and these remarkable Cycads. There is no doubt whatever that the characteristic vegetation of this age was Cycadean.

I have already mentioned the discovery of a few teeth of a true mammal near the junction of the Triassic and Oolitic rocks. We meet with other mammalian remains in the Stonesfield slate, a thin bed belonging to the middle of the Oolitic series. These latter also are either Marsupial, like the Opossums, or Insectivorous, and allied to the Hedgehogs. A third group of these fossils has been found at the upper part of the Oolites in what are called the Purbeck beds. These too are chiefly either Marsupial or Insectivorous—but amongst them are some other

s that may possibly belong to other classes of mammals, which require further investigation.

ut our time is slipping away, and we must now cross her boundary line and come to the Chalk. The Cretaceous are sometimes made up of sands and sometimes of chalk f ; the latter reveals to us a remarkable fact which the t German microscopist, Ehrenberg, was the first to find

FIG. 8.—Part of a Pinnated Cycadean leaf.

If you take a fragment of soft chalk from a Cambridge ry, you can easily brush it away in water until you resolve to white mud. Put a little of this mud under the micro- e, and you will discover that it is literally made up of the e objects known as Foraminifera.

Ve have here evidence of the truth of what I told you the

other day, viz., that some limestones, at all events, were not the products of any chemical action operating in the sea, but resulted from the agency of living creatures. As I have already stated, I am perfectly satisfied that the same remark can be made in reference to every limestone rock in existence, excepting those few fresh water Travertins about which I spoke an hour ago, and which are too insignificant in their amount to be taken into consideration when explaining the origin of limestone rocks. The Foraminifera which constitute chalk are very nearly related to the species filling up the bed of the Atlantic, and other seas in many parts of the globe, at the present day. Along with these Foraminifera, we now find an enormous number of organisms of various kinds which we have not met with previously. Thus during the Chalk age, sponges were at least more numerous and varied than at any previous period. At all events the number both of types and of individuals occurring in the Cretaceous strata many times exceeds what we find in any other part of the geological series. We also now find new forms of star-fishes, as well as of the tribe of sea-urchins so common on some parts of our sea-coast; but many of these new fossils present forms characteristic of the Chalk age and not found in any other rocks Turning to the Encrimites we again find a change. Most of the old types have gone, and are now represented by the extraordinary creature known as the Marsupite, from *marsupium*, a purse. This is simply an Encrinite without a footstalk. He had no footstalk, at least when grown up, though what he may have had in his babyhood I do not know. Star-fishes are living in the Frith of Clyde, which, in their infantile days, are supported upon a footstalk, but when they grow larger they detach themselves from it and float free. These Marsupites may have done the same. At all events the genus is very characteristic of the Cretaceous rocks. We still find remains of the Pterodactyle, the Mososaurus and the Ichthyosaurus. The Plesiosaurus is no longer there, but it is represented by the Pleiosaurus which much resembles it; these peculiar reptiles survived in diminished numbers, but as we leave the Cretaceous age they pass out of existence, to be replaced, as we shall see in our next lecture, by the modern types of lizards and crocodiles.

I have already spoken of the multiplication in the Cretaceous deposits of forms of shells allied to the Ammonite, and of

their final disappearance, along with the Belemnite, at this epoch.

But there are other remarkable vertebrate creatures yet requiring our attention. Two diagrams before you represent the lower jaws of two species of bird that have been discovered in the western regions of North America, by Professor Marsh, one of the first naturalists of America, who has found, at least, thirteen species of fossil-birds in the rocks of ths Cretaceous age. Some of these were met with on the Atlantic coast, and others in the far district of Colorado; the feature that is so remarkable about some of them, is that their beaks are furnished with rows of teeth as regular and definite as are those of any reptiles. This is a marvellous and unexpected fact. We have no bird with teeth at the present day. Anatomists of the evolutionist school naturally refer to these birds as indicating a transition state between reptilian forms and modern types of bird-organisation, and it is unquestionably true that they have very strong reasons for arriving at this conclusion. It is unquestionable that these objects are true teeth, each having a fang at its base, and having the upper part of each tooth covered with true enamel. Then the teeth are sometimes planted in a row of distinct sockets, whilst in others they are fixed in a groove, which shows a gradual approximation towards the development of sockets. Teeth like these must have belonged to carnivorous creatures. The two birds to which I am referring were both aquatic. One of them was about the size of a pigeon; but the other was a large diver, measuring about six feet from the tip of the beak to the end of the toes. It was a powerful bird, but, like the living Penguin, was unable to fly. Its wings were merely rudimentary ones. The supposition that this bird represents a form intermediate between the bird and the reptile, is further sustained by the circumstance, that, at the extremity of the upper jaw of this species, there were no teeth, but the jaw appears to have terminated in a horny beak. So that you have here combined the reptilian tooth with the beak of an ordinary bird; according to the evolutionists, as time went on, the beak grew bigger and the teeth grew less, until the latter finally disappeared. Thus there was handed down to future ages the race of feathered descendants which we see around us at the present day.

An extraordinary change came over the vegetation of the

world during the Cretaceous age; a change which not only affected the plants themselves, but the results of which reveal some remarkable phenomena connected with the distribution of heat and cold over the earth. In both the lower and upper parts of this Cretaceous series, we now find, for the first time, the representatives of living plants belonging to the flowering tribes comprehended under the name of Dicotyledons, and many of which are closely related to trees now flourishing in the forests of the world. We now come upon species of fig-tree, oak, beech, poplar, myrtle, willow, and magnolia, along with pines, ferns, and a host of other allied plants. The oldest of these Dicotyledonous plants with which we are accquainted is a species of poplar. We have seen that up to the commencement of the Cretaceous epoch, the only known plants have been pines, Cycads, and the various forms of cryptogamic vegetation; but recent discoveries have brought to light such a multitude of the higher forms of vegetation, from various parts of the world, that my two friends, Professor Heer, of Zurich, and Professor Lesquereux, of Columbus, United States, who are investigating these plants, run a fair risk of being overwhelmed by the multitude of specimens accumulating in their hands.

The climatal features to which I referred are quite as remarkable as the rapidity with which these new forms of vegetation multiplied and spread over the earth. Many of the specimens of this new vegetation have been brought to us from Greenland, a country which is now covered with ice, and where not a stick or leaf of a living tree will now grow; where, in fact, there is no vegetative life excepting the herbaceous plants that spring up during the brief summer. And yet in the age of which I am speaking, Greenland possessed magnificent forests, similar in many respects to those which now flourish in the warm Southern States of North America.

If you hunt through the forests of England and of midland Europe, you discover no species of magnolia or myrtle, fig-tree or Cycad, Tree-fern or Oleander, yet all these flourished in the ancient forests of Greenland. Some stupendous changes
[illegible]e evidently been wrought in the world since those days.
[illegible] very clear that the distribution of snow and ice was
[illegible]ifferent then from what it is now. Whether the earth's
[illegible]as got a twist, or whether in those days the globe was

whirling through some warmer parts of space than now surrounds us, is not easy to determine. The probabilities are against the idea of any change in the poles of the earth; but something strange must have occurred since the time when not only forests of magnificent trees overspread that Greenland continent, but when tropical genera of ferns, such as the Gleicheniæ, flourished as an undergrowth in even greater numbers than is the case with these ferns in tropical forests at the present day.

LECTURE III.

THE physical and vital agencies which modified the crust of the earth and its inhabitants through the long periods which occupied our attention in my first two Lectures, did not cease their action at the close of the Cretaceous age. They are producing similar effects now to those which they caused in the beginning of time, and probably with undiminished energy. But for a long period the effect produced by those agencies, subsequently to the Cretaceous age, were very ill understood. Until the early part of the present century what we now call the Tertiary rocks were almost altogether neglected. Baron Cuvier—one of the greatest of European naturalists—first showed the world that the Tertiary deposits in the neighbourhood of Paris contained the remains of strange and extinct animals. This discovery opened the eyes of geologists to the fact that there existed a series of superficial deposits, which eminently merited any amount of labour that might be bestowed upon them.

The important discoveries of Cuvier made a powerful impression on that great geologist whose death we had so lately to deplore—I mean Sir Charles Lyell. Lyell undertook the study of these neglected Tertiary beds. He endeavoured, and with a large amount of success, to reduce them to order by making use of the fossil shells which they contain. I may observe here that in all probability, if we except some Foraminiferous creatures of low organization, no one species either of plant or animal that lived previous to the close of the Chalk age, survived that period. Except one doubtful shell all the species found in the Mezozoic strata became extinct. None of them are to be found in any of the Tertiary strata. You will understand, however, the limitation with which I make [illegible] utterance. If the doctrine of evolution be true we are *descendants* of species that lived prior to the Chalk age,

But naturalists have hitherto applied the term "species" to individuals, the probability of whose descent from common parents is indicated, by the identity of their organization; groups of organisms are regarded, as being of the same species, when their individual members, are more like one another than they are like any other objects. The term species being thus defined, it becomes true, that all the Tertiary species are different from those which lived previous to the close of the Cretaceous age. Still less could any of the latter be identified with such as are now living on the earth. But when we cross the boundary line that separates the Cretaceous rocks from the Tertiary deposits, we begin to find the fossil remains of species that are still living. Lyell made use of this fact, and based upon it his classification of the Tertiary strata that we are about to study. He found that in the oldest of these Tertiary beds there was not more than about three and a half per cent. of recent shells in every hundred fossil species that he examined. Therefore he threw these oldest beds into one group, to which he gave the name of Eocene—a term signifying the dawn of recent life. In strata of newer age he found something like thirty-five per cent of living shells, associated with sixty-five per cent. of extinct ones. To this group of deposits he gave the name of Miocene—or less recent. Then when he came to other deposits of still more modern date, he found that the proportion varied from forty or fifty per cent. up to very nearly 100 per cent.; and to these he gave the name of Pliocene, or more recent.

The deposits to which Cuvier's attention was chiefly directed belonged to the Eocene period of life. I need not dwell upon the vast multitudes of shells that were found in them, though many of these were peculiar, including numerous genera not met with in the older rocks but which are amongst the most common of those now living. We thus learn that on crossing from the Cretaceous to the Tertiary beds even the molluscan forms of life underwent a sudden change. This is equally true of those which ceased to exist and of those which now appear for the first time. I have already pointed out in how marked a manner this statement applies to the Cephalopoda, or animals allied to the Nautilus and cuttle-fishes.

In our own country these Eocene strata are only found in the south-east of England, and especially in the neighbourhood of London and the Isle of Wight. In them we find the remains of reptiles, birds, and mammals. But the Ichthyosaurus and its

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companions are now replaced by the crocodile and the serpent. The latter creatures were as large as the tropical Boa-constrictors of the present day, and amongst them there was, according to Owen, a huge and veritable sea-serpent—though not having yet caught *the* great sea-serpent, I am not quite clear as to what his anatomical characteristics are. Then we have numerous turtles—rather smaller than the recent ones seen at aldermanic feasts. Fishes of many varieties now abound. The modern types which first presented themselves in the Chalk age now become the prevailing forms—replacing the Mezozoic and Palæozoic Ganoids which, though still represented become comparatively rare. Figure 9 represents the

FIG. 9.—Skeleton of a perch of the Eocene period, displaying the homocercal tail.

skeleton of a species of perch, from the slate-quarries of Glarus in Switzerland. This skeleton exhibits the *homocercal* tail, to which reference was made in a previous lecture. At the latter part of the Cretaceous age we find for the first time fishes allied to the salmon, perch, and many other forms living in our seas and rivers at the present time. You will probably remember I told you that no solitary fragment of those modern types of fishes to which Agassiz gave the name of Cycloids and Ctenoids, from peculiarities seen in the forms of their rounded scales, had hitherto been met with in rocks older than the Cretaceous series ; but towards the upper part of that group they begin to appear, and when we cross the

boundary and come to the Tertiary deposits these fishes crowd upon us in great numbers. Sharks of huge size were also common, as is shown by their numerous teeth preserved in the Eocene beds. But it is when we come to the Mammals, especially to those first discovered by Cuvier, that we are most strongly reminded of the changes which have overtaken the world's fauna.

When Cuvier first discovered the bones of these creatures he showed to the scientific world that, from the study of a limited number of bones, he could reproduce, with considerable probability, the entire animal. He did this by means of what he designated the law of co-relation, or, in other words, the mutual dependence of parts upon each other. That such restorations are possible within defined limits is doubtless true; but when I hear of their being accomplished by the examination of a fragment of a bone or of a tooth, I can merely smile at the world's credulity. If the combination of organs in the extinct animals had exactly corresponded with what we see in living ones, such feats of anatomical leger-demain might have been possible. But no man only possessing the skull of a Pterodactyle would have given to the animal the wings of a bat; neither would acquaintance with the skeleton of the body of Marsh's large Diver have led its discoverer to connect with it jaws full of enamelled teeth.

The chief quadrupeds which Cuvier found in these deposits were of two types; one of these was a heavy creature, somewhat like the pig; the other was an animal of much lighter construction. Cuvier showed, what we have no doubt now is perfectly true, that these were Mammalian animals, very closely allied to the Tapirs of which herds now roam through the South American forests.

The Tapir is a hog-like creature, but nevertheless not a true pig. It had its upper lip prolonged into a sort of proboscis, which was also the case with the Palæotherium. But Cuvier's other discovery, the Anoplotherium, was a creature of a much more graceful structure, and approached somewhat nearer to the Antelopes. The remains of these creatures are found not only at various points on the continent of Europe, but in England. Another Eocene mammal is the Hyænodon, which was probably one of the oldest of true carnivorous mammals.

We now meet with another well known group of animals not found in older strata—I mean the whales. In this lowest Eocene deposit there has been found, especially in the United

States of America, a huge whale furnished with very remarkable teeth, and known by the name of the Zeuglodon, and we know for a certainty that some of these Zeuglodons were fully seventy feet in length. Thus you see that though the giant Ichthyosaurus and other allied aquatic reptiles have disappeared from the sea, other huge marine creatures have taken their place, though of an entirely different class.

The general conclusion to which we are brought by the study of the animals found in these Eocene deposits is that at the period in which they were accumulated, the animal life on the globe was of a somewhat tropical character. This conclusion is further confirmed by the study of the plants of that age. We now find tropical palms, and associated

FIG. 10.—Skeleton of the Mammoth.

with them we have a large number of other plants, the seeds and fruits of which are yet preserved, all indicating the same general fact, namely, that the temperature at the period in question was very high.

But we must now cross another threshold and enter upon the Miocene age—in which we discover a marvellous outburst of that animal life, living forms of which now constitute so conspicuous a feature in the forests of India and Africa. We have probably no trace of these Miocene deposits in England; but when we cross to the Continent, we find them here and there in detached patches. As we proceed to the flanks of the Alps they crop up in larger masses, and an enormous *range of them* runs along the southern flank of the Himalayan

hills; these deposits are rich beyond any precedent in the remains of gigantic animals very similar to some now living. This remark applies to the Miocene deposits in various parts of the old and new world. We have now the Mammoth and the Mastodon—huge forms of Elephants; then we have the Hippopotamus, Rhinoceros, Bear, Hyæna, Monkey, Giraffe, Camel, and Deer of numerous forms. The Dinotherium was a huge elephantine animal but with two tusks projecting downwards from the lower jaw. The Sivatherium found in India, was a stag-like ruminant with two pairs of horns, and associated with it was a gigantic Tortoise eighteen feet long! I have said enough to show how marvellous and rapid has been the outburst of new forms of animal life, contrasted with its slow development in previous ages.

In dealing with the question of evolution we have carefully to consider the facts which I am now briefly enumerating. Recollect how extremely insignificant the thickness of the deposits that we are speaking of is compared with those of earlier date. The entire series of Tertiary beds is only represented by a very thin line even in any large section of the stratified rocks drawn to one scale. Yet, as I have already shown, the thickness of a series of deposits constitutes our best standard, imperfect though it be, for measuring the time which those deposits occupied in their accumulation. Remember then that in the lowermost part of the Tertiary series we have scarcely any of these mammals. The few found in beds of the Eocene period are but scanty representatives of the group; but when we turn a corner, it appears as if some great magician had waved his wand and, in response to the magic summons, life of the most varied character, and in forms most dissimilar from what immediately preceded, flash into existence.

The evolutionist has to explain these unprecedented phenomena, and to ascertain, if he can, how it is that this development of animal forms has proceeded so slowly through millions of years, and then at a very late period, as if in preparation for man's advent upon the earth, it should suddenly advance with such amazing rapidity. I contend stoutly that however numerous may be the facts that sustain the doctrine of evolution (and I am prepared to admit that there are many that do so in a remarkable manner) this unexplained outburst of new life, demands the recognition of some factor not hitherto admitted into the calculations of the evolutionist school.

Before we finally leave the Miocene age I would call your attention to the imperfect knowledge, not only of fossils, but of anatomy, which prevailed amongst naturalists in the early part of the last century. Scheuchzer, one of the most eminent naturalists of his day, obtained a skeleton of a large newt or Salamander from a quarry at Œningen, whence many similar skeletons have since been obtained. This he described, in more than one work, as the skeleton of a man who had been drowned in the Noachian Deluge. The fact that this Salamander rejoiced in the possession of a tail seems to have constituted no difficulty in the way of this primitive geologist. Both in size and form the Œningen reptile approaches very closely to a living Japanese species.

Leaving the Miocene we come to the Pliocene period, which has left its memorials, in the south-eastern counties of our own

FIG. 11.—(*a*) Œdipoda Haidingeri, a grasshopper from the Miocene beds of Radoboj in Croatia (after Heer). (*b*) Schellenbergia rotundata. A Miocene spider from Œningen in Switzerland (after Heer).

country in what is called the Crag of Suffolk, as well as in other parts of the world; we still find scattered amongst these deposits the remains of most of the Miocene Mammalia which continued to flourish, though the climate became much more temperate than it formerly was.

The detached Pliocene deposits are doubtless of various ages —but throughout the entire series we find numerous, still living, species either of marine or fresh-water shells; but curious changes have occurred in some of these species. Some which were very common in the Pliocene seas are now rare on our coasts, whilst with others the reverse is the case. There is no doubt that these shells indicate a change from *tropical to temperate* conditions. Nevertheless some of the

marine objects continue to be very remarkable. This is especially the case with the sharks, of which the fossil teeth are very numerous in what are called the Crag deposits. Many of these teeth are of enormous size. Comparing them with those of large living sharks, and assuming that the magnitude of the jaws increased in the same ratio as the teeth, we may fairly conclude that some of these fishes must have been able to open a mouth wide enough to take in the contents of a London Omnibus at one bite. Along with remains of the shark we now find bones of the true whale. These are not the Zeuglodons of the Eocene age, but whales of the modern type.

As the Tertiary age advanced we discover that the living types of vegetation became more and more abundant. You will recollect I called your attention to the fact that even at the close of the Cretaceous age poplars, myrtles, magnolias, and a whole host of other Dicotyledonous trees, belonging to warmer climes than ours, had begun to make their appearance on the earth. As the Miocene age passed by we find that the genera and species of these trees multiplied quite as rapidly as the quadrupeds. We further learn from the fossil plants that the distribution of heat and cold on the earth continued to be very different from what it now is. Thus, even in the Miocene age, parts at least of the ice-clad continent of Greenland were still clothed with rich semi-tropical forests in which district forms of plants were almost as abundant as they were at the close of the Cretaceous period. When those northern regions assumed their present condition we have yet to learn; but the change was probably coæval with the similar ones which affected the entire northern hemisphere after the close of the Pliocene epoch.

An age arrived when the semi-tropical conditions that prevailed in the periods of which I have been speaking, gradually yielded to influences of a more chilling character. Ice and snow began to creep southwards from the Arctic regions, until at last there arrived a time, now known as the Glacial age, in which the greater part of the northern hemisphere was covered with ice and snow, much in the way that Greenland is so clothed at the present time. How long this condition of
gs continued we do not know; but you will readily under-
d that such a physical change would necessarily produce
t alterations in the life of the period; and geology affords
proof that this was the case. We now find the Reindeer

feeding at the foot of the Alps; its remains, along wi
those of the Musk ox, supplies of which animal, you remembe
made a welcome addition to the scanty larder of the la

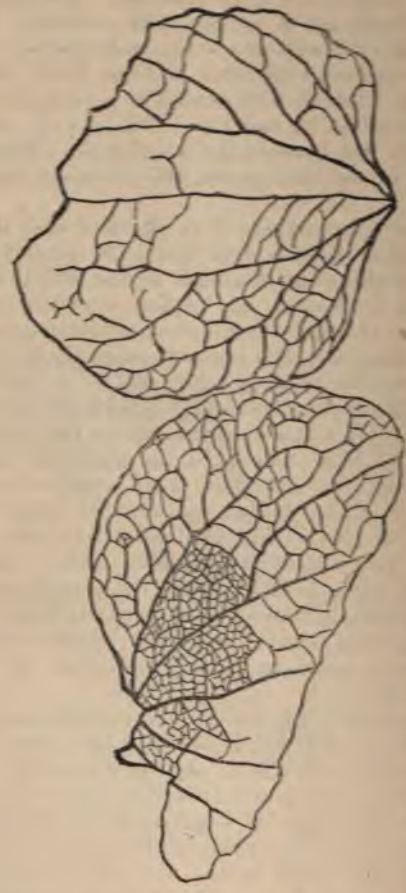

Fig. 12.—Leaves of a Miocene species of Poplar (*Populus arctica*) from Greenland (after Heer).

Arctic explorers, occur over the whole of northern and te
perate Europe, including our own country. The Glutton, anoth
Arctic animal, has also been found in a fossil state in some
these glacial deposits. To give even an outline of the histo

of this age would require a dozen lectures in order to do the subject justice. I should have to unfold to you the history of those wonderful ossiferous caverns which have been found in various parts of the world, and the investigations of which have been productive of such remarkable results. But time will not allow me to dwell upon these matters, beyond pointing out to you some of the more characteristic phenomena. On studying the Tertiary age generally, we cannot fail to see how much the world changed in one point as it grew older. At those periods which we examined in the two first lectures, we have every reason for supposing that animal and vegetable life presented a far greater uniformity than now from the Arctic to the Antarctic zones. Thus we find that the plants of the Coal measures of Australia are almost identical with those found in the Coal measures of Greenland and Spitzbergen, and the remark is equally true of the Coal measures of the intermediate zones. As the world grew older, and as we approach nearer to recent times, we find gradually springing up a tendency to local differences in the life characterising the different geographical areas; but at length we reach a period in which every country seems to have had its own distinctive animals, just as it has now. If I take you at the present day to the woods of South America, what do we find there? Amongst other things, numerous small Sloths hanging upon the trees, and feeding upon their leaves. In the Post-pliocene age Sloths were common in the same region, but they were as big as oxen, and consequently altogether unfitted for climbing up trees; but, as Professor Owen has shown, they were fitted for pulling the trees down. The same American province now abounds in Armadillos, which burrow into the soft soil as rabbits do in our own warrens; but amongst these we find the remains of an enormous extinct Armadillo, which must have been as big as a carrier's covered van. He was certainly above nine feet long from snout to tail.

If we cross to New Zealand, what do we find there? At the present time we have no Mammalia in New Zealand other than a rat and a bat. This fact possibly explains why the old New Zealanders were cannibal; if you realise that they had no domesticated animals such as we have, and that the only chance of getting meat was to eat their enemies, we can scarcely wonder that a savage race should see no harm in doing so. There has been found along with this rat and bat, the

Apteryx, a small species of wingless bird, about the size of a Cochin-China fowl. This bird belonged to the same group as the Cassowaries of Australia and New Britain. In the later Post-pliocene days, birds of this class were extremely numerous in New Zealand; but instead of resembling the living Apteryx in size, they were often larger than any living ostriches, some of them being fully ten feet high. Their bones are now scattered abundantly over the length and breadth of New Zealand; and it is clear that their extinction was due to the same agencies as destroyed the Dodo of the Mauritius. They were eaten by the natives as long as any remained; and when this game was no longer available, the New Zealander would be more likely than ever to eat his fellow-men.

A species allied to these New Zealand Moas, as they are called, has been found in Madagascar; we have also got the eggs, and it is calculated that one of them would contain about 148 modern hen's eggs. Thus you see that both in South America and New Zealand the animals that still live there are the representatives of others which lived in the same countries during a bygone age; but the living forms are the dwarfed representatives of the older giant race. In Australia the living animals are chiefly of the Kangaroo type, of which there are enormous numbers, both as regards individuals and species; and the remarks I made about New Zealand apply equally to Australia. We find in the caves of Australia fossil Kangaroos of the Post-pliocene age, and they were as much larger than those now living as the Megatheria and Moas of South America and New Zealand were larger than the Sloths and wingless birds of the present time. The point which I urge upon your attention is this—that the geographical distribution of animals at the present day does not differ, in many cases, from that which characterised the later geological ages. In the northern hemisphere this is true with an important limitation. We have already seen how during the Tertiary period the numerous Mammoths and their huge companions spread over the entire hemisphere. Then came the Ice age, which drove these creatures southwards, though we have evidence that both the Mammoth and the Rhinoceros were clothed with a covering of wool and hair, enabling them to endure a colder climate than can be borne by their modern representatives. At the same time they never were Arctic animals. They must have had vegetation upon which they *could browze*, and their companion, the Hippopotamus, must

have had unfrozen rivers in which it could swim. After the great invasion of ice passed away many of these animals returned to their old haunts; but they gradually disappeared one by one, leaving behind them only the wolf, the bear, the elk, and the deer to represent them in the temperate portions of the northern hemisphere at the present day—the larger forms of animals which formerly were their companions, and characteristic of the same great zoological province, having now retreated to the forests of Southern Asia.

After a period of unknown duration the ice began to recede northwards owing to a return of more genial suns. There is much difference of opinion amongst geologists as to the detailed succession of events during this age of milder temperature, but it is obvious that a struggle between sun and frost continued for a long period. There is much reason for supposing that after the first great Glacial age, the ice so far disappeared as to leave extensive tracts of land over which the Pre-glacial animals spread themselves, and that this very variable "Inter-glacial" period was succeeded by a return of the ice-sheet which again overspread parts of the temperate zone. Be this as it may, the ice-sheet finally disappeared, but its remnants lingered in the shape of numerous glaciers which long continued to occupy the gorges of our mountainous regions. During this later time the Mammoth and many of its Pre-glacial companions still roamed to and fro amongst our lower valleys and over our wide plains. At that time our island was not only united to the continent of Europe, but, in all probability, stretched far away southward and westward into the Atlantic. So that the ancient Europeo-Asiatic fauna was also the fauna of what is now Great Britain. The way in which the bones of southern forms of Mammalian life have become intermingled in caves and other Post-pliocene deposits makes their history a difficult one to render intelligible. This much however is certain. One by one these huge Mammals passed away from these latitudes. In all probability the latest survivor of the vast herds which once covered central Europe, but which do so no longer, was the noble species of deer known as the Irish elk; magnificent horns of this animal have been found varying from ten to fourteen feet from tip to tip, whilst his height was not less than ten feet; various facts have been brought to light, making it almost certain that this animal, at least, finally became extinct through human agency.

We now come to the most remarkable of all the phenomena connected with the history of life on the earth. I mean the appearance of man. Few are ignorant of the discussions which have taken place on this point, and of the wide differences of opinion that still exist in reference to it. On the one hand, there are geologists who believe that man existed in the age that preceded the first great invasion of Europe by the ice-sheet. Others who reject this conclusion admit that he must have dwelt in Europe in the Inter-glacial age, whilst a third school of *savants* deem the evidence of even this degree of antiquity unsatisfactory, but suppose that he came hither after the final disappearance of the ice-sheet. But there are few, even of the latter class of geologists, who deny that man's antiquity as a dweller on the earth was very great; few who do not admit that he saw the Mammoth and the Reindeer feeding on the plains of southern France, and hence that he dwelt as a hunter amongst the many extinct Mammals whose names I have brought before you.

But before I deal with some of the evidence upon which we must base our conclusions respecting man's age, I must direct your attention to the history of one Tertiary and Post-tertiary group of animals which have assumed the highest interest in in consequence of the speculations of Professor Huxley in reference to it.

You all know that each foot of the horse has only one toe, which bears its nail or hoof. But every farrier is aware that on each side of the "cannon" bone there are two "splint" bones, and which are undoubtedly the degraded remnants of the second and fourth toes of the ordinary five-toed Mammalian foot. The two outermost toes, viz.: the first and the fifth, are altogether wanting, and in the case of the second and fourth the "metacarpals" and "metatarsals" as they are called—that is the bones which form the palm of the hand and the arch of the foot—are present in the shape of the two "splint" bones to which I have referred. Unlike the third toe, these two lateral splint bones have no digits, *i.e.*, proper toes or fingers, at their free ends. But Professor Huxley long ago called attention to the fact that in Post-pliocene times, when our modern horse had no existence, there lived a species of horse the "Hippotherium" in which the two splint bones *were* terminated by digits, but which were too short to reach the ground and take any part in bearing the weight of the animal. Going *still further back* into the Tertiary age, Huxley pointed out

the remains of another animal, the Anchitherium, which resembled the horse in many of its features, but in which the subsidiary second and fourth toes, though still smaller than the principal central one, were yet capable of reaching the ground. Professor Huxley came to the conclusion that the Anchitherium had first developed into the Hipparion and the Hipparion into the horse, and that this history gave a very powerful support to the doctrine of evolution. He asks, Which is the more probable conclusion at which we can arrive: that Europe once sustained herds of Anchitheria, which were swept away, to be replaced, through some miraculous agency, with similar herds of Hipparions, whilst these in like manner were supplanted by herds of horses of the modern type; or that, by a process of evolution, each of these successive types has been developed out of the pre-existing one? Huxley unhesitatingly accepts the latter alternative, and argues that if this is the true history of the horse, something similar to it must have been equally the history of all other animals.

Two questions arise out of this hypothesis: first, is this a correct account of the genealogy of the horse, and, if so, does it follow that all other animals must have had a similar genealogy. In endeavouring to trace out the ancestry of beings whose pedigrees have not been preserved, but have to be ascertained by means of circumstantial evidence, we have but one kind of trustworthy evidence. If all the examples of Anchitherium exhibit peculiarities of a distinctive kind which separate them *by a definite line of demarcation* from the Hipparions, and if the latter in turn are equally distinct from the modern horse, we have no evidence that the three distinct gradations in the development of the foot were the result of a succession of minute and impalpable changes *in which one type shaded off into another*. Such gradations are met with in the organic kingdom in innumerable instances. But if, on the other hand, a long and linear series of specimens of these animals can be put before us exhibiting, not interrupted gradations, but such a gradual transition from the Anchitherium to the horse, as renders it impossible to discover a break in the long line, then Professor Huxley's conclusion that the Anchitherium was the ancestor of the Hipparion and the Hipparion of the horse, becomes inevitable, and we must accept it whatever other conclusions may be rendered necessary by our doing so. Until recently the evidence that there had been *such* a transmutation was not satisfactory

to me. But in a recent lecture Professor Huxley has brought forward some additional evidence derived from Professor Marsh's discoveries in the western states of North America. Beyond all question some of the gaps which have hitherto separated the three animals I have named, are filled up by these discoveries; but I want yet more evidence before I can arrive at the conclusion that the doctrine of evolution is proved by these facts beyond the possibility of question. It appears to me that before I can unhesitatingly give to the testimony of these fossil horses the full value which I am asked to do, I must know more about them than is at present possible. It will not be enough that the limbs and teeth of these creatures indicate transmutation, but such transmutation must be evidenced by every part of the animal. This demand is especially applicable to the stages which intervene between the Hipparion and the horse. If the latter was evolved out of the former during long periods of time, it must have been so evolved *as a whole;* not merely showing the gradual change progressing in some organs, but in every portion of its structure; myriads of individuals must have existed to effect this gradual shading of the one into the other in every part of its body. It is true that in the Pliohippus of Professor Marsh, the two lateral metacarpals had no digits, but even between this form and the abortive splint bone of the horse, there is yet a wide gap. Further researches may fill up this and other similar gaps. The facts now known undoubtedly increase the probability that the doctrine of evolution alone can explain the existence of this series of horse-like animals, but the recognition of this *probability* is a very different thing from the admission of absolute certainty, which is practically demanded of us.

But even admitting all that Professor Huxley requires us to do, so far as the genealogy of the horse is concerned, does it follow that we must at once recognize in evolution the process to which all other forms of organic life are due? To this question I can only give a negative answer. I have already expressed my conviction of the applicability of the doctrine to the explanation of many of the variations of organic life, and I think it impossible to exaggerate its value as a working hypothesis; but beyond this I am, as yet, unable to go and for this reason: assuming Professor Huxley's hypothetical genealogy of the horse to be historically true, it only demonstrates what we already believed to be a fact, viz., that

changes in the surroundings of living organisms were capable of producing corresponding changes in those organisms *within certain limits*. In the present case we have only one part of the problem solved by nature's experiment. We have only the degradation, from disuse, of certain pre-existing organs—a process which throws no light whatever upon the opposite class of facts, in which entire organs make their appearance which had no previous existence. Animals already so closely allied to each other as to represent collectively the equine type, *began* with five toes, four of which successively disappear so far as only to be represented by the imperfect splint bones of the living horse, but we do not learn from these facts how animals originally became possessed of toes of any kind. Such information may be obtained from other sources or it may not—but the history of the horse certainly does *not* furnish us with it.

After this preliminary inquiry we may now proceed to ascertain what light has been thrown upon the corresponding history of man.

As is well known, numerous ancient relics have been found in various places, intimately associated with the remains of extinct animals, which no rational being can refuse to recognise as works of art fashioned by human hands. Rude works they are in many cases—but yet such as no unintelligent forces could have produced. The bone needle with its perforated eye, found by Mr. Pengelly in Kent's cavern, and the magnificent flint weapons which have been met with in so many localities, are illustrations of what I mean. The human origin of these objects being established, the all important point remaining to be proved is their age. Did the extinct animals, with whose bones these works of art are found associated, live into comparatively late ages, or did man exist in the remote period when Britain was a part of the European continent, and when the western extension of that continent stretched far out into the Atlantic?

There has been found one special set of memorials of a yet more interesting kind. I have already told you that as one of the consequences of the glacialisation of the northern hemisphere the Reindeer at one time abounded in southern France, where its remains now occur. Remarkable outlined sketches of these and other animals have been found in the same district, graven on pieces of their horns, on ivory, and on fragments of slate. In Sir John Lubbock's work

on the *Origin of Civilisation and the Primitive Condition of Man*, a book within the reach of all my hearers, you will see represented (p. 21) a group of Reindeer fighting, which was found in the south of France, and which could only have been delineated by some one familiar with these animals. In the same work is a still more remarkable outline scratched rudely on a piece of a Mammoth's tusk, and found in the Cave of La Madeleine in the Dordogne. From the sketch of the Mammoth given on page 46 it will be seen that the tusks of that animal curve upwards and inwards in a way that differs very widely from those of all living elephants; further, we know, from specimens found in Northern Siberia, that, unlike any of the living elephants, the anterior part of the Mammoth's body was hung with masses of long hair. Both these remarkable features reappear in the Dordogne sculpture. It seems to me extremely improbable that the ancient artist, even had he seen an African elephant —itself a very improbable supposition—would have so far diverged from his model as to reproduce exactly the two characters which distinguished the extinct Mammoth from its living representatives. The reproduction of one of these features would have been a remarkable coincidence; but that the two should be conjoined only appears explicable on the supposition that the artist had lived side by side with the extinct creature whose outlines he so accurately transferred to a fragment of one of its own tusks. The Esquimaux of the present day depict the animals living around them upon fragments of their own skeletons, and it appears to me that the men of the Post-glacial period, at which period we know that the Reindeer and the Mammoth flourished in southern Europe, only did the same. It is very improbable that a savage who had never seen a Mammoth could have elaborated it from his inner consciousness; he could merely have copied, as the Esquimaux do, such creatures as he was familiar with. I think we cannot avoid coming to the conclusion that, whatever may have been the age at which the sculptor of that animal lived, he was familiar with it; he used its ivory as one of the materials upon which to exercise his art; and we are consequently driven to the conclusion, that, however old or young man may be, he lived upon the earth at the time of these extinct animals. We next ask, in what shape does he personally present himself to us. We are told by the evolutionists that he was originally a monkey. This is not necessarily an

improbable fact; we must not scout the idea merely because we are apt to smile at it; we must look at the evidence upon which the hypothesis rests. There is no doubt whatever that man is constructed upon the same type as the monkey, and that when you put their skeletons side by side, though there are certain points of difference, there are greater and stronger points of resemblance. Consequently, *à priori*, assuming that the doctrine of evolution is true, it would be extremely probable that man had developed out of one of the larger and more man-like types of ape. If we merely study man's skeleton as a whole, I can obtain from it no evidence that necessarily upsets the conclusions of the evolutionists; but when we come to study certain special features, I think I see very grave difficulties. In the first place, when we examine the brain-pan of the monkey and compare it with that of man, I need scarcely say how large is the difference between the magnitude of the human brain and that of the highest type of monkey that we are familiar with. Of course it is very difficult to decide how much these differences are worth. We sometimes find a man with a little brain made of superior material, who, mentally, surpasses another man with a bigger brain made of baser material. But let us see to what this comparison of brain-power brings us. The largest Gorilla has a brain of about thirty-four and a half inches of cubic capacity; but this magnitude is exceptional; generally speaking, the brain of the Gorilla has from thirty to thirty-two inches of cubic capacity. The brain of the highest form of intellectual man has about 114 inches of cubic capacity. Between these two extremes there is an enormous difference. But the evolutionist properly says, "I have nothing to do with extremes; I have only to study the highest form of ape and the lowest form of man, to see if a link can be found uniting the two."

The smallest known adult human brain, respecting the accuracy of the measurements of which there exists no room for doubt, is one described by Professor Marshall of London. It is that of a Hottentot woman; we do not know her age or whether or not she was an idiot. When we find the brains of Englishmen and Europeans with a less cubic capacity than about sixty inches, we are told by Dr. Davis, one of our highest authorities on this subject, that they are invariably those of idiots; but it does not follow that this brain capacity would necessarily indicate idiocy in savages. The brain of the Hottentot woman measured sixty-two and a half cubic inches.

The evolutionists argue that since there is such a diversity in the brain of humanity, varying from 114 cubic inches to sixty-two, there is no reason why we should not go down to thirty inches and reach the level of the Gorilla. I contend that this is not a philosophical argument, and I will tell you why. Suppose you try to stretch a cord already three feet long, you may easily add some inches to its length; but having done this you will find it far more difficult to stretch it another inch than you did to stretch it the first half-dozen. You have reached the limit of its elasticity, and, use what effort you may, any further strain only snaps it in two. Apply this to the human brain. It is true there is an elasticity in the development of this organ that admits of its ranging between 62 and 114 inches, but because you have got so low as 62 inches it does not follow that it could be reduced in size to the extent of 28 inches more. I think this statement is sustained by archæological evidence. The two oldest human crania that have yet been found are those known as the Engis and Neanderthal skulls. Of these the former was unquestionably the more ancient. Yet Professor Huxley admits that it has probably a cubic capacity of 75 inches, and might have belonged either to a negro or to a philosopher. The Neanderthal specimen is much more imperfect, hence its exact capacity is not easily calculated; but it was probably much inferior to the Engis one, though its owner lived at a later period of time than was the case with the Engis savage. We thus see that the facts exhibited by the oldest known skull carries us far away from the Gorilla, and leave us solely dependent upon possibilities in attempting to build up our hypotheses. I am brought to the conclusion, that, so far as the skull is concerned, there is a wide gulf yet to be bridged over, deeper than the uncompromising advocates of evolution appear to recognise. But it is not to brain measurements, nor to any other merely structural peculiarities, that I am inclined to look for evidence bearing upon this problem—but to the psychological peculiarities which separate man from the most exalted of the lower creatures. The caves of the Dordogne reveal primæval man to us as an artist—rude, it is true, yet using his flint stones as graving tools, and sculpturing, with these imperfect implements, life-like representations of the creatures amongst which he lived. Now what have we in any Gorilla that prepares us for these manifestations of artistic *talent?* *Literally* nothing: yet this is only one of the in-

numerable mental and moral potentialities which separate man from the brute. It appears to me unphilosophical to say that these powers have been produced by the influence of man's surroundings acting upon his organisation. I would urge that all that those surroundings have effected has been, not to create, but to call into activity, powers that were already latent in man's nature. When we talk about what civilisation has gradually accomplished, we must remember that civilisation has proceeded from the exercise of qualities residing *within* man himself, and not from physical influences operating from *without*—hence civilisation, so far from being a product of the "surroundings" of Mr. Spencer, is merely a proof of the existence in man of latent potentialities, which no surroundings could create, however much they might aid in stimulating them into activity. As it is, there is no race of men so degraded that they cannot be taught in the course of a very few generations to display mental qualities to which the mere animal, however long he may have dwelt within the influence of civilised man, can lay no claim. Man can not only look backwards by an effort of memory, but anticipate the possible joys and sorrows of the future, which no animal can do. He can entertain abstract conceptions of good and evil, of beauty and its opposites, of right and wrong. He can work out the most intricate intellectual problems by processes even more intricate than the problems to be solved; and finally, when we regard man in the loftiest of his relations, we find him in possession of a sense of responsibility, not only to his fellowmen, but to the Supreme Ruler of the Universe; he has almost always some abstract conception, however vague, of a Being whom his eye hath not seen, but to whom his instincts tell him that he must one day render an account of his doings whilst on earth, and from whom he expects to receive a future life; a hope in which the most developed of brutes has no part.

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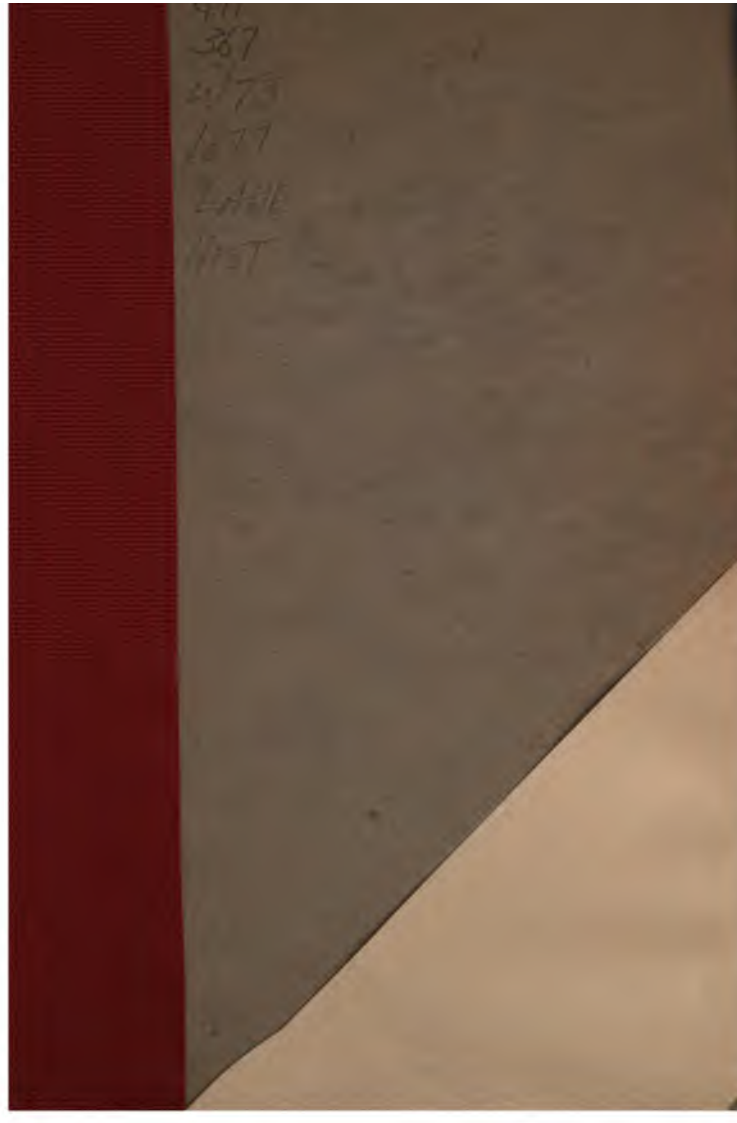
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